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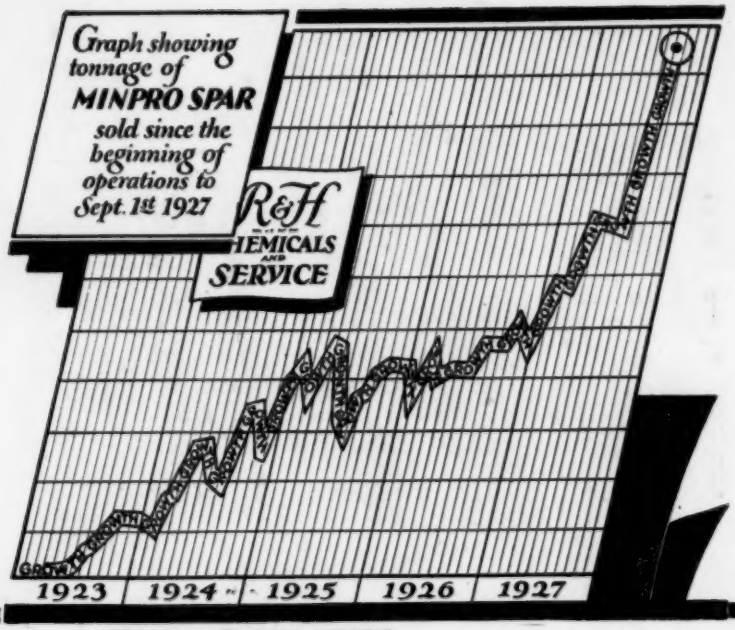

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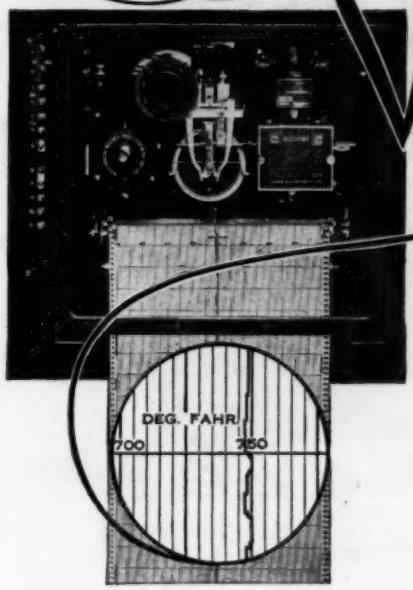

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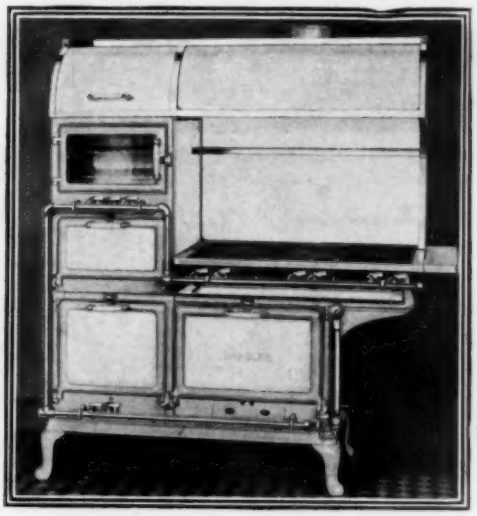

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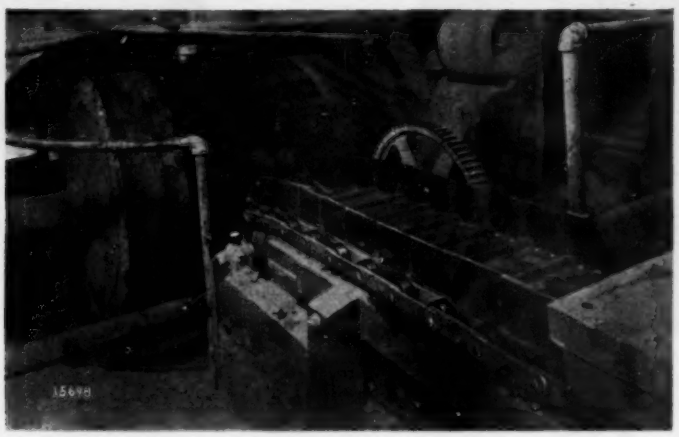

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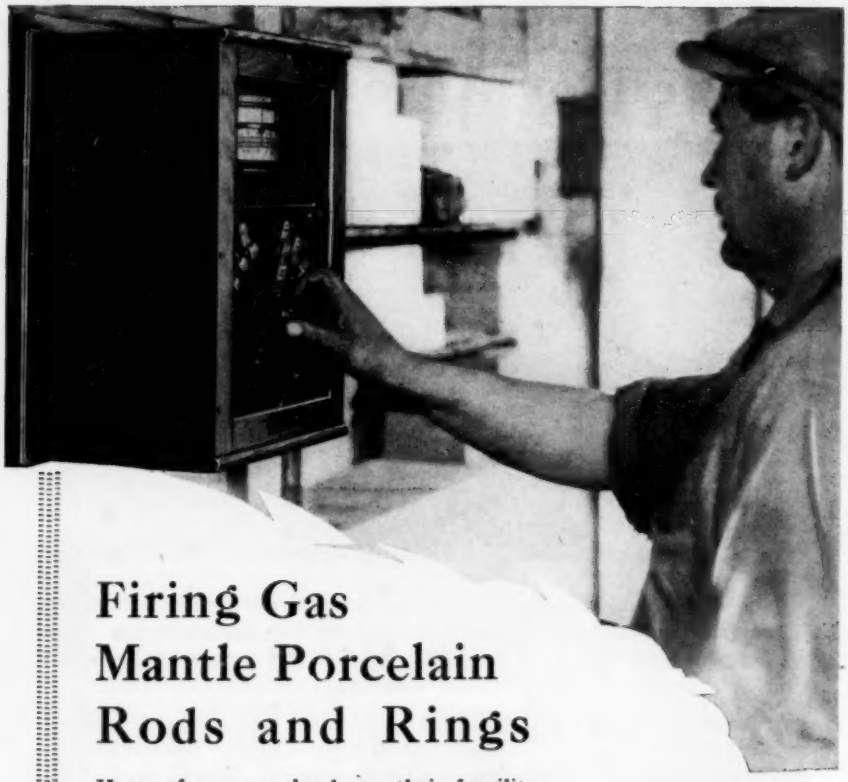

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THE VACUUM SLIP PROCESS OF REMOVING AIR FROM CLAY BODIES[1]

By G. W. Lapp

ABSTRACT

In this process the slip clay is passed through a tank and the air content is evacuated by boiling out. The ability of the clay filter cakes formed from this slip to reabsorb a small amount of air insures freedom from air in the pugged clay if the pug mill is efficient as it can be in compacting the clay, without adding appreciable air to the clay.

Freedom from gases results in a series of helpful conditions throughout the various stages of production.

Introduction

In the preparation of clay by the slip method it is possible to extract from the slip the air content which is present as gaseous bubbles and also in the form of air dissolved in the water of mixture. The gaseous bubble content is determined by a method of compressing the slip or the clay in a chamber. The total gas content is found by expanding the gases in a vacuum or by heat. Immediately before boiling the air comes out of solution. The slip has been at or above saturation point in respect to the gas or air it can hold in solution. When it is rid of this air content by vacuum treatment it is below saturation at room temperature and pressure. It is then greedy for air and if the treated slip is pumped into the filter press the plastic clay in the resulting cakes is capable of taking up or dissolving again a small volume of air before gas as such is present in the clay.

If the leaf clay is then pugged as usual a small amount of air is again incorporated into the clay. It is possible to develop the pug mill to a point where the additions of air in several puggings do not exceed the amount that the clay can redissolve as shown by the absence of compressible voids. Figure 1 shows air content in pugged clay of various kinds. Bodies *A* and *B* were pugged in one mill which decreased the air in *A* and increased it in *B* when pugged a second time. Figure 4 and Figure 1*C* show absence of collapsible voids in vacuum treated clay when pugged in a highly developed mill.

Free gas in plastic clay is a major evil. It weakens the bond, lowers the density, and causes occasional pits, blebs, and fissures. These faults cause low and erratic mechanical strength in the porcelain. In addition they become the subtle locus of dielectric puncture paths. Cracks due to other causes can usually be detected and remedied by changes in manipulation or design but any flaws due to nonuniformity in the body itself depreciate porcelain as a responsible material.

Elimination of the major evil of gases in the clay does not solve all problems but the improved integrity of the clay body is helpful in the operations of pugging, forming, drying, and firing.

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February 1927. (White Wares Division.) Received December 13, 1927.

Manufacturing Process

A description of the process used will give a better idea of the effects on the other operations. Separate clays are blunged and lawned and the body as a whole is blunged and lawned, then ground for several hours in pebble mills and lawned again into the stock slip cistern. From this cistern it does not go directly to the filter press pump as usual but it flows up as high as eighteen feet into the top of the vacuum-treating tank because of the reduction in pressure in the tank. Flow of slip into this treating tank is controlled by a float valve to maintain the level near the bottom of the tank leaving the upper three quarters empty for treating the slip as it flows in a thin layer down the sides of

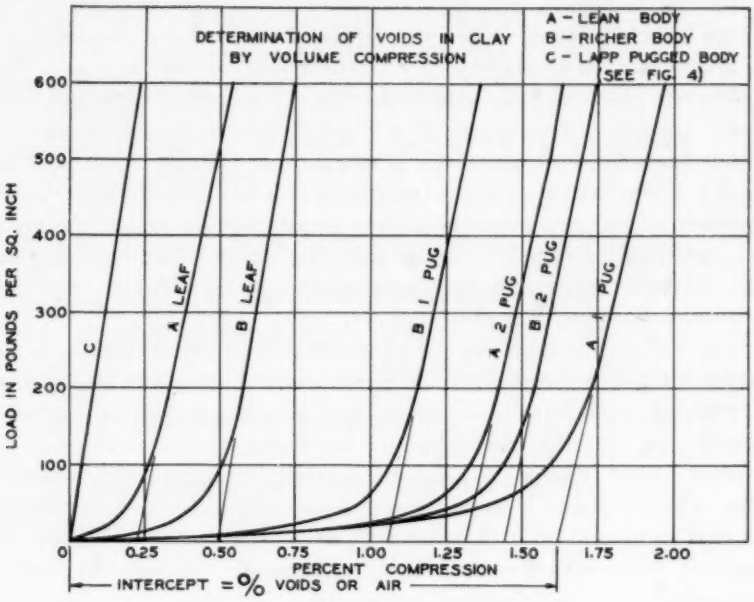

FIG. 1.

the tank exposed to the full action of the vacuum without any hydrostatic pressure head. The pressure in the tank is reduced by means of an ejector condenser jet to a point that is limited only by the boiling point of the slip itself. That is, a small part of the water in the slip is boiled out with the air. This enormous expansion of water vapor into the extremely minute milky bubbles that form throughout the slip causes the air content to flash out completely, ridding the slip in an instant.

The heat of vaporization for this expanding water vapor is furnished by the heat of the body of the slip which is distributed ideally throughout the mass, intimately available to help expand and burst each tiny nascent bubble of air.

The treated slip flows down flat (Fig. 5) and is pumped out of the bottom of the tank by the filter pump. Only as slip is pumped out does the float valve permit more to flow in to maintain the level.

Benefit in Manufacturing

(1) Completeness of air removal is evident from the fact that the pump readily pumps the slip from the vacuum tank with 100% volumetric efficiency against a suction head of about 32 feet of water which is nearly three times as great a suction head as was formerly had pumping directly from the slip cistern. And when the untreated slip was pumped at the lower suction head it was a regular necessity to blow off the air from the plunger pump chambers as they became air bound and refused to pump. This caused variations in the pump pressure on the filter presses and nonuniformity of consistency in the clay. Considered merely as a helpful adjunct to the pump and presses the treating tank would be amply justified.

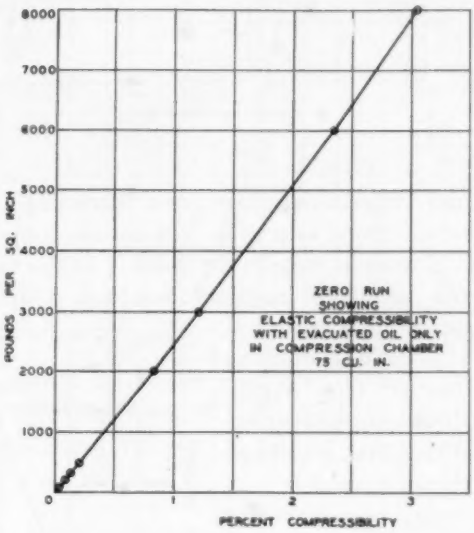

FIG. 2.

(2) The second benefit realized from vacuum treatment was the elimination of a second pugging, and at times a third pugging, of the clay which had always been necessary to avoid laminations. Clay laminations and flaws which had always been imminent were eliminated and at the same time it was found possible to pump the press cakes harder and pug the clay at a consistency almost 100% higher than previously when raw slip was used. This capacity to heal successfully clay almost twice as hard permits the pugging of tubular blanks and the extrusion of special shapes to much better advantage because they hold up better without a multitude of special forms of receiving equipment.

(3) Thicker walls in tubular blanks can be run and dried successfully from which can be turned one-piece bushings of the highest responsibility with integral watersheds.

(4) It is not necessary to age the clay, as plasticity in the clay is realized immediately.

(5) In a healthy body, healing power is vigorous, not yielding to minor ills which harass the person of delicate health. When a clay body was secured with a margin of freedom from flaws and with self-healing or absorbing power, many of the pampering practices formerly considered necessary, fell into disuse. Instead of shunning drafts, batteries of fans blow room air against the ware. A perfectly good artificial humidifying system in the driers was discontinued, and the rate of drying increased. Drying difficulties are cumulative. A differential distribution in the sizes and shapes of pore spaces, causes variable capillary conductivity and differential directional shrinkage, which overstresses the weak bond. Bond cracks do not always come to the surface in thick bodies.

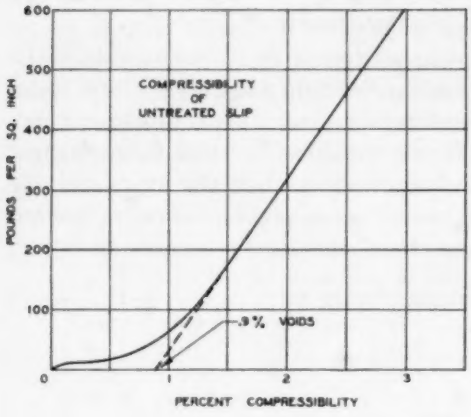

FIG. 3.

The most important bond is at the two troweled surfaces formed by the passage of pugging members. One per cent of air may not sound like a serious amount. It is quite enough to flavor the high-shrinking colloidal slimes that appear at these troweled surfaces. One per cent of a one inch cube is a small cube .21 inch on a side. Clay having one per cent of gaseous voids is different material from clay that is capable of dissolving one per cent of air. Even before we can measure a percentage of gaseous voids there is a subtle difference in bond as shown by bending 180° flat $\frac{1}{2}$ inch thicknesses of clay that have been pugged once, twice,

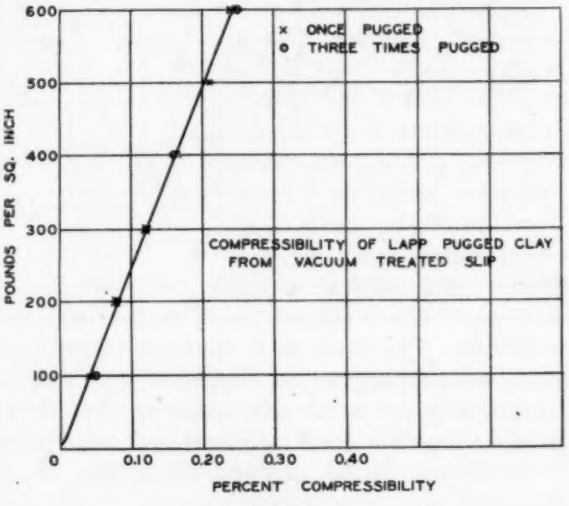

FIG. 4.

and three times. Clay with a capacity for more air can be pugged intensively with a large increase in temperature without going bad. Small sections pugged with a large mill cause the clay to stiffen up and refuse to flow. It appears that a small percentage liberation of air along with heating and working makes the clay short.

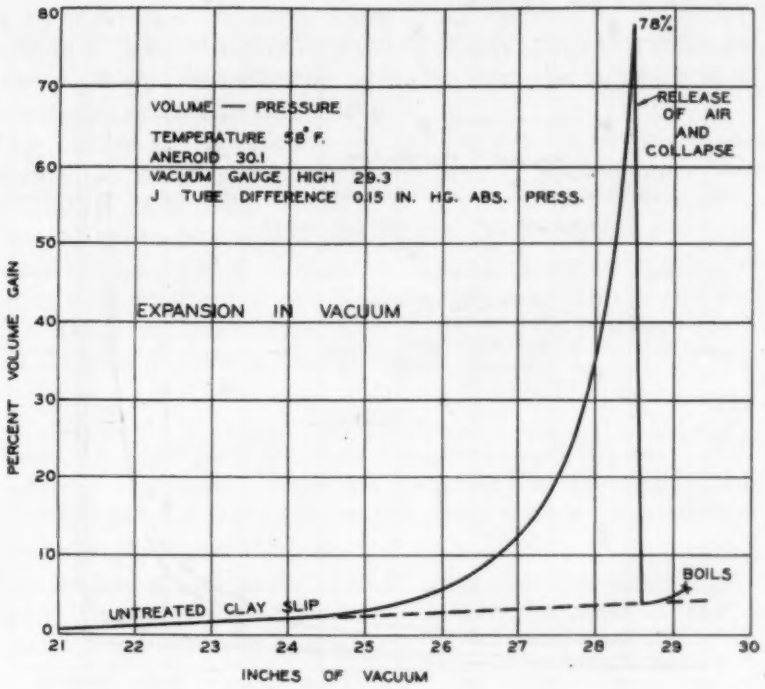

FIG. 5.

Benefits in Ware Produced

There appears to be a relation between the air content in the clay and density of fired ware. Elimination of the collapsible voids in the plastic clay has increased the density of the fired ware about 2% with the same body thoroughly vitrified in both cases. The mixed-in-air content is in the form of bubbles of gas of a much higher order of size than the true water pores between the graded grains of the body materials. These true pores in a fat body are exceedingly small. They occupy nearly 50% of the wet clay volume and nearly 30 % of the dry clay volume, judging by total shrinkage and firing shrinkage.

The ingested air pores are larger and they are nonshrinking during part of the drying period for the air cannot migrate. These pores find difficulty in shrinking during firing because of the relatively small power

of surface tension to collapse a large pore. When the viscosity has lowered sufficiently for the larger pore to shrink, it finds itself occluded in the melt, a closed pore. It may be that it plays its rôle as the villain to the last act, insisting on shrinking during the annealing period when the lesser pores have become extinct and the grains are happily united in a peaceful state of vitrification.

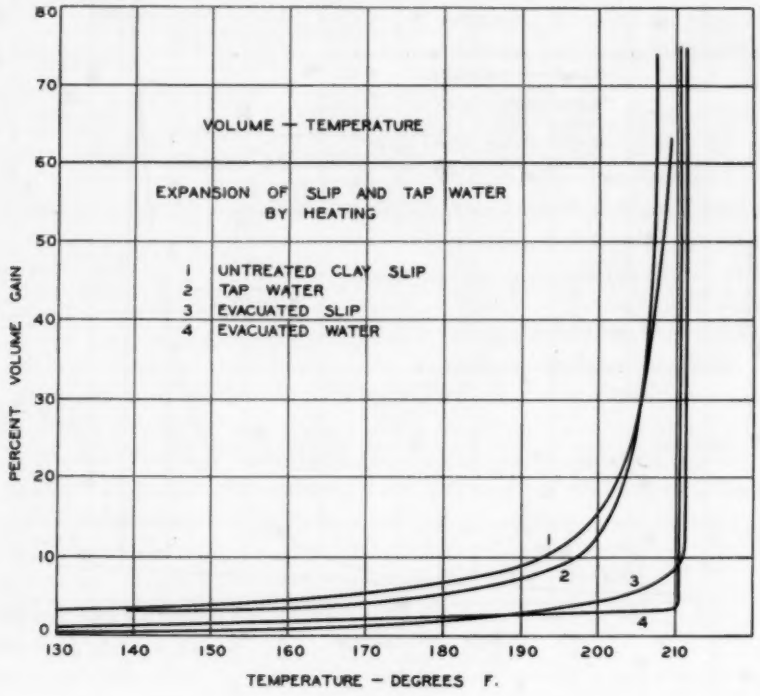

FIG. 6.

Determination of Air Content

The method of determining air content consists in mechanical compression of the sample in a liquid filled chamber. A plunger with special packing developed by Prof. Bridgeman of Harvard, was forced down into the compression chamber by means of an 80,000 pound Riehle test machine. Any gaseous volume was readily collapsed and dissolved in the water present in the sample of slip or clay. This method gives a direct determination of the voids actually present at atmospheric pressure, by plotting the results and continuing the straight line of rigid compression until it intercepts the displacement axis at zero pressure. Determinations are readily made to one-hundredth of one per cent. This method is believed to be new. It

offers a simple accurate way of determining voids in collapsible or porous material. It is of value in investigations of pug mill operations and the aging of clay. Figure 1 illustrates results.

Vacuum Treatment of Casting Slips

The vacuum treatment of slip used in casting should improve the cast by preventing pinholing which is one evidence of air in the slip. The form of pinhole that enlarges as it goes in is due to a small bubble at the mold surface gathering other air from the incoming slip and increasing in size as the cast thickens.

Slip freed of air by vacuum treatment would, by tending to absorb any small air bubbles, prevent the growth of these pinhole bubbles and insure a dense cast generally.

The slip pump feeding the casting line can pump the slip from the vacuum-treating tank and circulate it back to the stock slip cistern treating it on the average several times as it passes through the vacuum tank. This repeated treatment occurs on slip that escapes the relief valve on the pump line to filter presses.

Conclusion

About six years' daily use of the vacuum process applied to clay slip for removal of gaseous content has demonstrated its value in elimination of laminations and improving uniform soundness of plastic wet process electrical porcelain body.

The method of testing for voids by direct compression is of general interest because of its applicability to other purposes as well as to investigations in the clay industry.

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FURTHER STUDIES ON PORTLAND CEMENT COMPOUNDS BY THE X-RAY DIFFRACTION METHOD[1]

By W. C. Hansen

ABSTRACT

In this investigation a study has been made of methods for preparing compounds of CaO with Al_2O_3 and SiO_2 which may occur in Portland cements. The products from the different methods were studied microscopically and by the X-ray diffraction method, and the X-ray diffraction patterns for γ and β $2CaO \cdot SiO_2$ and $3CaO \cdot SiO_2$ are given.

Introduction

The purpose of this investigation was: (1) to study methods of preparing the compounds of CaO with Al_2O_3 and SiO_2 which according to the work of Rankin and Wright[2] might occur in Portland cement and (2) to identify the compounds present in mixtures of these oxides when such mixtures are heated under definitely controlled conditions.

It seemed that this investigation should furnish information which would be of value in correlating the differences of opinion now existing regarding the nature of the compounds of CaO with Al_2O_3 and SiO_2 occurring in Portland cement.

Both microscopic and X-ray diffraction methods[3] were used in this study. Each method has certain limitations that the combined methods tend to overcome. If two compounds have very similar optical properties it is difficult to identify them by microscopic examination in any preparation. The X-ray diffraction patterns of the two compounds may be very different and the presence of the two easily determined by this method. If a compound tends to crystallize in very small crystals, microscopic studies are not satisfactory whereas such crystals are easily studied by the X-ray method. It is possible, however, to determine very small amounts of crystalline materials in mixtures by microscopic examination provided the crystals are of sufficient size and of sufficiently different optical properties. This is not true for the X-ray diffraction method. Concerning the latter Wyckoff states[4]:

> The limits of detection of crystal species will depend upon such factors as the excellence of the pattern produced by each of the crystalline components of the unknown, their relative amounts and the amount of amorphous or glassy material present. These limits have not yet been evaluated but it is known that the method is unsuited for small amounts. For example, in mixtures of two oxides of the same element, it was found impossible to detect with certainty less than 10% by weight of one in the presence of 90% of the other.

[1] Publication approved by the Director of the Bureau of Standards U. S. Department of Commerce. Paper No. 12 of the Portland Cement Association Fellowship at the Bureau of Standards. Received November 25, 1927.

[2] G. A. Rankin and Wright, *Amer. Jour. Sci.*, **39**, 1 (1915).

[3] The powder method of Debye and Hull was used.

[4] The Structure of Crystals, The Chemical Catalog Co. Inc. 1924, p. 419.

A few data on this point have been obtained in this investigation and will be presented later.

From the study made by Rankin and Wright[2] on the system $CaO–Al_2O_3–SiO_2$, it appeared that four compounds of CaO with Al_2O_3 and SiO_2 might be present in Portland cement clinker.[5] They are $3CaO \cdot SiO_2$, $2CaO \cdot SiO_2$, $3CaO \cdot Al_2O_3$, and $5CaO \cdot 3Al_2O_3$. These compounds may be divided into three classes as follows:

(1) Compounds that melt congruently. A compound is said to melt congruently if at its melting point the solid and liquid in equilibrium have the same composition. $2CaO \cdot SiO_2$ and $5CaO \cdot 3Al_2O_3$ belong to this class.

(2) Compounds that melt incongruently. At the melting point of such compounds the liquid and solid in equilibrium have different compositions. $3CaO \cdot Al_2O_3$ is an example of this class. At $1535° \pm 5°$, $3CaO \cdot Al_2O_3$ dissociates into CaO and liquid.

(3) Compounds that dissociate into solids without melting. At $1900° \pm 20°$, $3CaO \cdot SiO_2$ dissociates into CaO and $2CaO \cdot SiO_2$. No melting takes place until 2065° is reached. At that temperature the eutectic mixture of CaO and $2CaO \cdot SiO_2$ melts.

Compounds that melt congruently at temperatures below 1700° are easily prepared. A carefully prepared mixture of the finely powdered components can be melted in platinum and maintained in the liquid condition long enough for diffusion to establish homogeneity. Then by careful cooling and annealing complete crystallization may be obtained. Compounds that melt above 1700° are not so easily prepared because of the difficulty of getting crucibles to withstand those temperatures without reacting with the melt. Compounds of classes (2) and (3) are not stable in the presence of liquids of their own composition and, therefore, are difficult to prepare.

Preparation and Properties of Pure Compounds

The raw materials used were precipitated calcium carbonate, alumina, and silica ground to pass a 200-mesh sieve. The partial chemical analyses[6] of these are given in Table I.

Ten to 15 grams of each of the compounds were prepared by each of the methods to be described. The initial mixtures were made by stirring the finely-powdered raw materials together in a beaker with distilled water. These were dried over a hot plate and stirred as evaporation proceeded to prevent segregation.

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[5] X-ray diffraction patterns of the two aluminates have been reported from this laboratory by E. A. Harrington, *Amer. Jour. Sci.*, **13**, 467 (1927).

[6] By H. C. Stecker.

$5CaO \cdot 3Al_2O_3$ This compound[2] melts congruently at $1455° \pm 5°$. It crystallizes in the isometric system and has an index of refraction of $1.608 \pm .002$. A mixture of $5CaCO_3 + 3Al_2O_3$ was melted in an electric furnace[7] in platinum. This melt was ground to a fine powder, remelted, and cooled slowly. Microscopic examination showed the product to consist of isotropic crystals $N = 1.608 \pm .003$. Occasional grains of $3CaO \cdot Al_2O_3$, $N = 1.710 \pm .003$ were observed. This sample was used for the X-ray diffraction pattern given in the earlier paper.[5]

TABLE I

ANALYSIS OF RAW MATERIALS

	Calcium carbonate	Alumina	Silica
CaO	55.73	nil	0.15
SiO_2	nil	.01	99.37
Al_2O_3	0.08	98.50	0.35
Fe_2O_3	.01	.002	.02
MgO	0.01		
Alkalis	.04		
CO_2	44.10		
SO_3	trace	trace	
Cl	trace	trace	
Loss on ignition	44.10	1.42	0.21

$3CaO \cdot Al_2O_3$ This compound[2] melts incongruently at $1535° \pm 5°$. It crystallizes in the isometric system and has an index of refraction of $1.710 \pm .002$.

The method of preparation of this compound is given in outline form:

(1) A mixture of $3CaCO_3 + Al_2O_3$ was heated[7] in platinum in the electric furnace at $1375° \pm 10°$.

(2) Product of (1) was reground and reheated at $1375° \pm 10°$.

(3) Product of (2) was reground and reheated at $1375° \pm 10°$.

The temperature 1375° was chosen because $5CaO \cdot 3Al_2O_3$ and $3CaO \cdot Al_2O_3$ form a eutectic mixture which melts at $1395° \pm 5°$. The formation of liquid makes the product a little more difficult to grind and for that reason was avoided.

Microscopic examination of product from (3) showed it to be made up of isotropic crystals $N = 1.710 \pm .003$ and a trace of CaO. Most of the crystals of $3CaO \cdot Al_2O_3$ contained very small isotropic spots that appeared to be inclusions. None of the other aluminates could be detected. The trace of free CaO probably was due to a slight error in weighing out the raw materials.

Since these crystals contained what appeared to be inclusions it seemed advisable to test the purity of the material by thermal studies. This was done by wrapping small charges in platinum foil and heating them to various temperatures. After being maintained for a certain

[7] W. C. Hansen and R. H. Bogue, *Ind. Eng. Chem.*, **19**, 1260 (1927). Unless otherwise stated, the method of heating these preparations was the same as described in that paper.

time at the desired temperature the charge was quenched by dropping it into mercury. The treatments given these charges and the results of microscopic study of the charges are given in Table II.

TABLE II

HEAT TREATMENTS GIVEN CHARGES OF PRODUCT 3 OF $3CaO \cdot Al_2O_3$ AND RESULTS OF MICROSCOPIC STUDY

	Temperature ± 5°	Time in minutes	Microscopic results	Remarks
A	1400	15	No change in crystals	No sintering
B	1425	15	" " " "	" "
C	1500	15	" " " "	" "
D	1525	45	Inclusions diminished	Slight sintering
E	1530	60	" "	" fusion
F	1550	15	Melted, glass of $N = 1.683 \pm .003$	Some free CaO

The results of these treatments show that the final product did not contain any of the lower aluminates and that the inclusions were probably gas bubbles or vacuoles. The crystals in the 1530° charge were not deformed although the charge appeared to have fused a little.

X-ray diffraction patterns obtained from products 1, 2, and 3 and from charges E and F, were found to be identical. These materials were the source of the X-ray diffraction pattern of $3CaO \cdot Al_2O_3$ previously published.[5]

$2CaO \cdot SiO_2$ According to Rankin and Wright[2] this compound occurs in three enantiotropic modifications. The optical properties and inversion temperatures of the three modifications as determined by them are given in Table III.

TABLE III

OPTICAL PROPERTIES AND INVERSION TEMPERATURES[2] OF THE THREE MODIFICATIONS OF $2CaO \cdot SiO_2$

Modification	Crystal system	Indices of refraction ± .002 α	β	γ	Optic axial angle	Optical character	Inversion temperature
γ	Probably monoclinic	1.642	1.645	1.654	$2E = 52°$	−	γ to β 675°
β	Orthorhombic or monoclinic	1.717		1.735	large	+	β to α 1420°
α	Monoclinic or triclinic	1.715	1.720	1.737	large	+	α melts 2130°

The β to γ inversion is accompanied by a 10% increase in volume which causes the material to disintegrate to a fine powder. This phenomenon is commonly known as dusting. The inversions of α to β and β to γ are very rapid and ordinarily it is extremely difficult to prevent them by quenching the pure compound. In the ternary systems such as $CaO–Al_2O_3–SiO_2$[2] and $CaO–MgO–SiO_2$[8] it is possible

[5] Ferguson and Merwin, *Amer. Jour. Sci.*, **48**, 81 (1919).

to quench melts containing $2CaO \cdot SiO_2$ and prevent the inversions. Bates and Klein[9] found that small amounts of B_2O_3 and Cr_2O_3 were very effective in preventing the β to γ inversion.

$\gamma 2CaO \cdot SiO_2$ This compound is easily prepared. The reaction of $2CaCO_3 + SiO_2 \rightarrow 2CaO \cdot SiO_2$ is very rapid above 1200° and the inversions of α to β to γ are rapid upon cooling and appear to be complete.

The sample studied was prepared by heating the correct mixture twice in the electric furnace at about 1450°. The product dusted completely. Microscopic examination showed complete inversion to the γ modification. The X-ray diffraction pattern of this preparation is given in Table IV.

$\beta 2CaO \cdot SiO_2$ Sample 1 was prepared by the method described by Bates and Klein[9] using 1% B_2O_3.

Sample 2 was prepared from the $CaCO_3$ and SiO_2, the analyses of which are given in Table I, without the addition of any foreign oxides. The method was as follows:

The mixture of $2CaCO_3 + SiO_2$ was heated in the electric furnace[7] at about 1450°. This product which dusted was mixed thoroughly by rolling on paper and reheated to 1450°. Upon cooling it did not dust and microscopic examination[10] showed the presence of only traces of the γ modification. Most of the material appeared to be $\beta 2CaO \cdot SiO_2$ having as refractive indices $\alpha = 1.717 \pm .003$ and $\gamma = 1.735 \pm .003$.

The reason for the failure of this product to invert to the γ modification has not been determined. Attempts to repeat this result by starting with the same raw materials have given the γ modification regardless of the number of heatings and the temperature of heating. A partial chemical analysis[6] of this sample gave the following results:

	Found	Theoretical $2CaO \cdot SiO_2$
CaO	64.64	65.00
SiO_2	34.70	35.00
R_2O_3	.43	
Loss on ignition	.02	

Sample 2 of $\beta 2CaO \cdot SiO_2$ has been kept for over a year without any apparent change. The X-ray diffraction pattern of Sample 2 was identical with the one obtained from Sample 1 in which B_2O_3 was used to prevent the inversion. This pattern is given in Table IV.

A charge of Sample 2 was heated in the quenching furnace for an hour at 1550° and quenched in mercury. Microscopic examination[11] showed it to be made up principally of twinned grains. Rankin and

[9] Bur. Stand. *Tech. Paper*, No. 78 (1917).

[10] By F. W. Ashton.

[11] By Herbert Insley.

Wright[2] claim that twinning is characteristic of the α modification. Interference figures obtained on grains of this sample were biaxial positive with a small optic axial angle. Rankin and Wright[2] reported the optical character of both α and $\beta 2CaO \cdot SiO_2$ as biaxial positive with large optic axial angle. Since even the grains on which interference figures were obtained showed evidence of intricate twinning it is possible that the apparent size of the optic axial angle has been decreased by the twinning. Indices of refraction were not noticeably different from those of the β form of $2CaO \cdot SiO_2$. The X-ray diffraction pattern[12] of this sample was identical with that of the original Sample 2. If this sample was in reality $\alpha 2CaO \cdot SiO_2$, the X-ray diffraction patterns of α and β are identical.

A charge of Sample 2 was heated to 1350° for one hour and quenched in mercury. This was done to allow any of the α modification that might be present to invert to the β modification. The X-ray diffraction pattern[13] of this sample was identical with the others.

A sample of CaO 55, MgO 7, SiO_2 38, was fused three times and then a small charge was held at 1475° for an hour and quenched. The above composition falls in the field[8] in which $\alpha 2CaO \cdot SiO_2$ separates as a primary phase. This composition at 1475° should have been composed of $2CaO \cdot SiO_2$ and liquid. Microscopic examination[14] showed the quenched charge to be composed of $2CaO \cdot SiO_2$ and glass. Interference figures showed these crystals to be either uniaxial or biaxial positive with a very small optic axial angle. The X-ray diffraction pattern obtained from this sample was identical with those obtained from the other samples of $\beta 2CaO \cdot SiO_2$.

Rankin and Merwin[15] in their report on the $CaO–MgO–Al_2O_3$ system make the following statement regarding the $CaO \cdot Al_2O_3$ found in that system:

> The value of $2V$ of this compound ($CaO \cdot Al_2O_3$) in silicate preparations is given as 36°; variations to nearly uniaxial were observed during this investigation. Besides irregular grains and fibers many crystals which appeared to be orthorhombic were observed. No variations in refractive index from crystals found in the silicate melts were noted.

Dyckerhoff[16] and Gillson and Warren[17] found crystals in Portland cement which had small optic axial angles but nearly the same refractive indices as $\beta 2CaO \cdot SiO_2$. The small optic axial angle was

[12] Determined by E. A. Harrington.
[13] Determined by L. T. Brownmiller.
[14] By L. T. Brownmiller and H. Insley.
[15] *Jour. Amer. Chem. Soc.*, **38**, 568 (1926).
[16] Dissertation, Univ. of Frankfurt, 1925.
[17] *Jour. Amer. Ceram. Soc.*, **9** [12], 783 (1926).

taken by them as an indication that the crystals in question were not $\beta 2CaO \cdot SiO_2$.

It would seem from the results obtained on $2CaO \cdot SiO_2$ in this study and from those obtained on $CaO \cdot Al_2O_3$ by Rankin and Merwin that the size of the optic axial angle alone is not a safe criterion to use in identifying a crystalline phase in such mixtures as Portland cement.

These studies reported in this paper do not show any difference in the X-ray diffraction patterns of α and $\beta 2CaO \cdot SiO_2$. If twinning is characteristic of the α modification alone both the α and β forms were studied. It has been suggested[18] that the inversion from the α to the β form is so rapid that it is impossible to prevent the inversion by quenching and that the α modification has never been obtained. The tendency of the β form to twin is accentuated by the strains set up by inversion so that twinning is characteristic of those samples made by inversion from the α form while the β form not showing twinning is only seen in occasional grains produced by heating below 1420°.

$3CaO \cdot SiO_2$ This compound dissociates[2] without melting into two solids at $1900° \pm 20°$. Its optical properties are: Uniaxial positive or biaxial positive with small optic axial angle, very weak birefraction not over .005, and mean index of refraction $1.715 \pm .002$.

The reaction $2CaCO_3 + SiO_2 \rightarrow 2CaO \cdot SiO_2$ proceeds rapidly at temperatures above 1200° while the reaction $2CaO \cdot SiO_2 + CaO \rightarrow 3CaO \cdot SiO_2$ is extremely slow at temperatures up to 1600°. Rankin observed that CaO became less reactive when it was heated at high temperatures. The methods followed in this study were designed to avoid this decrease in the reactivity of the CaO.

Since pure $3CaO \cdot SiO_2$ must be prepared without melting it is not possible to obtain it except as small crystals. The purity of such fine-grained material is not easily determined by microscopic examination. In order to make certain that the X-ray diffraction pattern obtained was that of $3CaO \cdot SiO_2$ and not of a mixture of compounds three different samples were studied.

First Sample The method used in the preparation of this sample is given in outline form below:

(1) $2.3CaCO_3 + SiO_2$ were well mixed and heated in platinum in the electric furnace for about 1 hour at 1500°.
(2) Product from 1 was reground with 0.3 $CaCO_3$ and reheated.
(3) Product from 2 was reground with $0.3CaCO_3$ and reheated.
(4) Product from 3 was reground with 0.1 $CaCO_3$ and reheated.
(5) Product from 4 was reground and reheated.

Microscopic examination of this material showed it to consist principally of an extremely fine grained, weakly birefracting phase with a

[18] Private communication by Herbert Insley.

mean index very close to 1.715. Besides this phase traces of free CaO could be detected.

Second Sample The procedure followed in the preparation of this sample[19] was similar to that of the first except a large quantity of material was used and the heatings were made in a gas-fired furnace.

Third Sample Since CaO reacts slowly with $2CaO \cdot SiO_2$ to form $3CaO \cdot SiO_2$ it seemed that the reaction might be hastened by using an excess of CaO and later removing it. Hot absolute alcohol and glycerine will dissolve a limited amount of CaO which can be neutralized with alcoholic ammonium acetate[20] thus allowing more to dissolve without causing any disintegration of $3CaO \cdot SiO_2$.

The procedure followed in preparing this sample is outlined below:

(1) A mixture of $4CaCO_3 + SiO_2$ was heated for about one hour at 1500°.

(2) Product from (1) was ground with enough distilled water to form a stiff paste and reheated at once. It was expected that the little water added, upon heating would hydrate some of the free CaO and restore its reactivity, and at the same time not be sufficient to cause disintegration of the $3CaO \cdot SiO_2$.

(3) Product from (2) was examined microscopically and found to be largely $3CaO \cdot SiO_2$ (N about 1.715 and birefraction very weak) and CaO. There were some crystals of $\gamma 2CaO \cdot SiO_2$ present as shown by their medium birefraction and lower indices of refraction. This sample was reground with water and reheated.

(4) Product from (3) still contained some grains of $\gamma 2CaO \cdot SiO_2$ so it was reground with water and reheated.

(5) Product from (4) contained traces of $\gamma 2CaO \cdot SiO_2$. The CaO was dissolved in hot absolute alcohol and glycerine and neutralized with alcoholic ammonium acetate. The sample was filtered and washed once with absolute alcohol and reheated.

(6) Product from (5) contained a little free CaO. This was removed as outlined above and the sample reheated.

Product from (6) was analyzed[6] and found to have the following composition:

	Found	Theoretical $3CaO \cdot SiO_2$
CaO	73.62	73.59
SiO_2	25.88	26.41
Al_2O_3	0.29	
Loss on ignition	0.03	

(7) A small charge of the product from (6) was heated for forty-eight hours at 1500°. Microscopic examination showed this product to be made up of very weakly birefracting grains with a mean index close to 1.715; traces of higher birefracting grains and CaO were observed.

[19] Prepared by Wm. Lerch.

[20] Wm. Lerch and R. H. Bogue, *Ind. Eng. Chem.*, **18**, 739 (1926).

The X-ray diffraction patterns obtained from the three samples of $3CaO \cdot SiO_2$ were the same. This pattern is given in Table IV.

An interesting observation was made during the preparation of this third sample of $3CaO \cdot SiO_2$. The product obtained from the first heating at 1500° contained a large amount of $2CaO \cdot SiO_2$ which was in the γ form. ($\gamma 2CaO \cdot SiO_2$ is distinctly prismatic and has a very characteristic appearance.) The product obtained from the third heating at

TABLE IV

X-RAY DIFFRACTION PATTERNS OF $\gamma 2CaO \cdot SiO_2$, $\beta 2CaO \cdot SiO_2$, AND $3CaO \cdot SiO_2$*

$\gamma 2CaO \cdot SiO_2$		$\beta 2CaO \cdot SiO_2$		$3CaO \cdot SiO_2$	
Planar spacing	Relative intensity†	Planar spacing	Relative intensity	Planar spacing	Relative intensity
4.31	*W*	2.88	*W*	3.02	*SS*
3.80	*W*	2.77	*SS*	2.75	*SS*
3.35	*W*	2.74	*M*	2.59	*SS*
3.00	*S*	2.60	*M*	2.44	*W*
2.88	*W*	2.54	*W*	2.32	*M*
2.74	*SS*	2.44	*W*	2.18	*SS*
2.61	*W*	2.39	*W*	2.07	*W*
2.52	*W*	2.28	*W*	1.973	*M*
2.45	*W*	2.18	*S*	1.925	*M*
2.33	*W*	2.11	*W*	1.824	*M*
2.19	*W*	2.08	*W*	1.761	*SS*
2.04	*W*	2.05	*W*	1.626	*S*
1.970	*W*	1.975	*M*	1.536	*M*
1.905	*S*	1.895	*M*	1.485	*S*
1.800	*M*	1.793	*W*	1.449	*W*
1.752	*M*	1.695	*W*	1.384	*M*
1.690	*W*	1.620	*M*	1.300	*W*
1.630	*M*	1.568	*W*	1.271	*W*
1.523	*W*	1.545	*W*	1.227	*W*
1.490	*W*	1.518	*W*	1.193	*M*
1.472	*W*	1.483	*W*	1.158	*M*
1.440	*W*	1.410	*W*	1.128	*M*
1.405	*W*	1.383	*W*	1.091	*M*
1.355	*W*	1.360	*W*	1.066	*W*
1.255	*W*	1.286	*W*	1.042	*W*
1.235	*W*	1.243	*W*	1.022	*W*
1.160	*W*	1.209	*W*	.992	*W*
1.135	*M*	1.176	*W*	.969	*W*
1.095	*W*	1.150	*W*	.954	*W*
1.013	*W*	1.132	*W*	.888	*W*
0.960	*W*	1.097	*W*	.839	*W*
0.895	*W*	1.073	*W*	.821	*W*
0.830	*W*	1.056	*W*		
		1.039	*W*		
		0.983	*W*		
		0.956	*W*		
		0.906	*W*		
		0.854	*W*		

* Determined by L. T. Brownmiller.
† *SS* = very strong; *S* = strong; *M* = medium; *W* = weak.

1500° contained many crystals that had the appearance of $\gamma 2CaO \cdot SiO_2$. Their mean index of refraction and birefraction, however, corresponded to those of $3CaO \cdot SiO_2$. That seemed to indicate that $\gamma 2CaO \cdot SiO_2 + CaO$ reacted to form $3CaO \cdot SiO_2$. Such a reaction did not seem possible, since $\gamma 2CaO \cdot SiO_2$ exists only below 675°. It seemed more

plausible to believe that $2CaO \cdot SiO_2$ retained the structure of the γ modification for a time at temperatures above the inversion temperature of 675°. To test this a sample of $\gamma 2CaO \cdot SiO_2$ was held for an hour at 1400° and quenched. Under the microscope the sample looked very much like $\gamma 2CaO \cdot SiO_2$ but its indices of refraction corresponded to those of $\beta 2CaO \cdot SiO_2$. After a few hours, inversion took place without any apparent change in the structure of the crystals but with a decrease in their indices of refraction to those of the γ modification. Therefore, it appears that $2CaO \cdot SiO_2$ retains the apparent structure of the γ modification for some time at temperatures above the inversion temperature of $\gamma 2CaO \cdot SiO_2$. The $3CaO \cdot SiO_2$ formed by the combination of this $2CaO \cdot SiO_2$ with CaO retains the $\gamma 2CaO \cdot SiO_2$ appearance. Forty-eight hours of heating did not seem to have any appreciable effect upon those crystals of $3CaO \cdot SiO_2$.

X-ray Studies on Mixtures of CaO, Al_2O_3, and SiO_2

Having the X-ray diffraction pattern of the various compounds formed in mixtures of CaO, Al_2O_3, and SiO_2, in which the concentrations of the components are close to those found in Portland cement, it was possible to follow the course of the reactions of certain mixtures during heating by means of X-ray studies.

Two different compositions heated to four different temperatures, 1300°, 1350°, 1400°, and 1450°, were studied. The compositions were: CaO 70 and 67, Al_2O_3 11 and 12, SiO_2 19 and 21.

The amount of uncombined CaO in each sample was determined by the method described by Lerch and Bogue.[20] These results are given in Table V.

TABLE V

COMPOUNDS PRESENT IN PREPARATIONS OF CaO, Al_2O_3, AND SiO_2 AS DETERMINED BY THE X-RAY DIFFRACTION METHOD

	Composition 1 CaO 70, Al_2O_3 11, SiO_2 19 Temperature of heating				Composition 2 CaO 67, Al_2O_3 12, SiO_2 21 Temperature of heating			
	1300°	1350°	1400°	1450°	1300°	1350°	1400°	1450°
$3CaO \cdot SiO_2$	−	+	+	+	+	+	+	+
$\beta 2CaO \cdot SiO_2$	+	+	+	+	+	+	+	+
$\gamma 2CaO \cdot SiO_2$	−	+	+	+	+	+	+	+
$3CaO \cdot Al_2O_3$	+	+	+	+	+	+	+	+
$5CaO \cdot 3Al_2O_3$	−	−	−	−	−	−	−	−
CaO	+	+	+	+	+	−	−	−
Percent CaO determined	18.5	15.3	4.7	2.7	13.2	2.4	2.3	negative

The results of the X-ray study of these mixtures[12] are given in Table V. The compounds that may be present are listed and in the body of the table the plus signs indicate that the compound was present and the negative signs that it could not be detected.

From this study it is seen that $3CaO \cdot SiO_2$ forms at 1300° under the conditions of these experiments in a mixture of CaO, Al_2O_3, SiO_2 of the composition of number 2.

Dyckerhoff[16] believed the formation of $3CaO \cdot Al_2O_3$ took place in the following manner: $CaO + Al_2O_3 \rightarrow CaO \cdot Al_2O_3 + CaO \rightarrow 5CaO \cdot 3Al_2O_3 + CaO \rightarrow 3CaO \cdot Al_2O_3$. Experience in this laboratory seems to support that belief. The formation of $5CaO \cdot 3Al_2O_3$ is very rapid at temperatures around 1300° while that of $3CaO \cdot Al_2O_3$ is somewhat slower.

It was surprising therefore not to find $5CaO \cdot 3Al_2O_3$ in any of the samples so two mixtures were made up and studied to determine what concentration of this compound was necessary to be detectable. The first mixture had 5% $5CaO \cdot 3Al_2O_3$ carefully mixed with $3CaO \cdot SiO_2$ 40, $\beta 2CaO \cdot SiO_2$ 25, $\gamma 2CaO \cdot SiO_2$ 15, $3CaO \cdot Al_2O_3$ 15. The second one contained 10% $5CaO \cdot 3Al_2O_3$ mixed with the above compounds, the $\gamma 2CaO \cdot SiO_2$ being decreased to 10%. The aluminate could be detected in the second, but not the first. Therefore, there must have been less than 10% of $5CaO \cdot 3Al_2O_3$ in the mixtures given in Table V.

Composition 1, heated at 1450°, was found to contain 2.7% free CaO. Some lines of CaO were visible in the diffraction pattern but hardly intense enough to be able to state positively that the sample contained CaO. It would seem, therefore, that it requires more $5CaO \cdot 3Al_2O_3$ (probably about 7.0%) than CaO (about 3.0%) to be identified in such mixtures by the X-ray diffraction method as used in this study.

Summary

(1) Methods are given for the preparation of $5CaO \cdot 3Al_2O_3$, $3CaO \cdot Al_2O_3$, $3CaO \cdot SiO_2$, $\gamma 2CaO \cdot SiO_2$, and $\beta 2CaO \cdot SiO_2$.

(2) Attempts were made to prepare $\alpha 2CaO \cdot SiO_2$. In one sample of $2CaO \cdot SiO_2$ the crystals were intricately twinned which according to Rankin and Wright is characteristic of the α form. This sample gave the same X-ray diffraction pattern as did the samples in which the crystals were not twinned. An explanation of this is given.

(3) Two mixtures of CaO, Al_2O_3, and SiO_2 were heated at four different temperatures and the products studied by the X-ray diffraction method. The compounds identified in those products were $3CaO \cdot SiO_2$, γ and $\beta 2CaO \cdot SiO_2$, $3CaO \cdot Al_2O_3$, and CaO.

Bureau of Standards
Washington, D. C.

THE LOSS OF SILICA DURING GLASS MELTING[1]

By S. R. Scholes

ABSTRACT

Repeated analyses of glass taken from an operating tank at different times show that, when round-grained and dustless sand is used, the silica found in the glass averages 0.64% lower than the value calculated from the batch. When sharp-grained dusty sand is used, the loss is greater, amounting to 1.13%. This loss is suggested as the reason for sharp-grained sand being easier to melt than round-grained, leaving less silica for fusion. These results are confirmed by the data from other analysts, showing that the percentage of silica found is usually smaller than that calculated for a given glass.

Loss Due to Volatilization

Alkalis The assumption is often made, that in the process of melting glass in a tank, some of the alkali is volatilized. If this were the case, we might expect to find the checker-brick in the regenerators glazed, if not slagged, by the alkali carried over by the flue-gases. As a matter of fact, when tanks are properly operated and high flame velocities avoided, the deposits in the checkers are of a dusty character, and there is little evidence of fused material.

Moreover, if the alkali of the batch were volatilized to a marked extent, we might expect the composition of the glass to show a lower value for soda than that calculated from the batch, unless the loss by volatilization of other oxides occurred at such a rate as to balance losses. On the contrary, analytical results on tank glass commonly show that the alkali content is somewhat higher than the batch composition would foretell, and that the silica is the component showing a lower value.

Dust Loss

Fine Silica The writer's attention was drawn to these facts when it seemed advisable to demonstrate by analysis whether or not the glass was different in composition (as it was reported to be different in working properties) after a change in the type of sand used. One of these sands was produced by grinding a hard rock, was made up of sharp grains, and contained about 5% dust or "flour" passing a 100-mesh sieve. The other sand was produced from a loosely bonded sandstone, made up of rounded grains, and contained no fines or dust.

Twelve samples of glass from each sand were analyzed for silica. The method was the usual sodium carbonate fusion and two acid evaporations, the ignited silica being finally tested for purity by hydrofluoric acid evaporation.

In arriving at a conclusion regarding silica values, it was considered fair to average the results, since this would offset sampling variations

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February 1927. (Glass Division.) Received Oct. 21, 1927.

and analytical errors. When this was done for each set of determinations and the silica values compared with the percentage calculated for the glass from batch composition, it was found that the glass contained in each case less silica than the batch composition indicated; in the case of the glass from round-grained sand, it was 0.64% lower, and where sharp-grained dusty sand was used, it was 1.13% lower.

Conclusion

It thus appears to be demonstrated that silica is the component suffering the greatest loss during the melting process, and that the finer the particles of silica introduced, the greater the loss.

The difference of about .5% in silica content between two glasses of equal batch weights throughout but made from different sands, serves to explain the slight difference in working properties observed by the workmen, and it may have another significance. It is an old belief in glass factories that sharp sand melts more easily than round-grained sand. Perhaps the difference, if any, lies in the fact that more of the latter sand remains to be melted after the flame currents have played across the batch piles floating in the tank.

The disappearance of part of the round-grained sand may be due to actual volatilization of silica, as such, at tank temperatures.

In conclusion, the writer wishes to mention communications from several glass analysts, corroborating the above results as to loss of silica.

FEDERAL GLASS COMPANY
COLUMBUS, OHIO

INFLUENCE OF OXIDIZING AND REDUCING AGENTS ON SELENIUM GLASS COLORS[1]

By Alexander Silverman

ABSTRACT

The effects of oxidizing and reducing agents on the colors produced in selenium glasses are discussed.

Selenium produces a ruby color in zinc-potash glasses in the presence of cadmium sulphide and a reducing agent. An amber shade is obtained in lead glasses in the presence of an oxidizing agent. In lime glasses a pink color is obtained in the presence of an oxidizing agent without the use of cadmium sulphide, and an orange shade when cadmium sulphide and a reducing agent are added. No mention has been made in the literature of the last three colors in the particular types of glasses, so the writer submits this note hoping that chemists and ceramists may ascertain the cause of the color produced by selenium under various conditions.

The red color of the zinc-potash glasses is already attributed to the formation of polyselenides. This would imply the action of a reducing agent. The amber color in lead glasses might be attributed to lead selenide were it not for the presence of an oxidizing agent. The pink color in lime glasses certainly results under oxidizing conditions, for niter is employed, and the glass does not have to be reheated to produce the color. The orange color in lime glasses forms in the presence of cadmium sulphide and a reducing agent, and changes somewhat on reheating. It is probably the result of reducing action.

As previously stated, the element selenium produces a number of colors under various conditions. Can the ceramists and chemists offer any explanation for the behavior of this versatile color-producing element?

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (Glass Division.) Received Sept. 13, 1927.

THE USE OF FUSED SILICA AS A RAW MATERIAL IN THE MANUFACTURE OF PORCELAIN[1]

By A. E. R. Westman[2]

ABSTRACT

The effect of different forms of silica commonly used in porcelain bodies on their properties is compared with that produced by use of fused silica. Sources of fused silica are discussed. Comparative tests were made on two bodies, typical of electrical porcelain commonly manufactured in the United States, the only difference between them being that one contained Ottawa sand flint while the other contained powdered fused silica. The firing behavior and thermal expansions were determined and a microscopic examination of thin sections was made. The fused silica body differed materially from the porcelain and due to its difference the name "fusilain" has been suggested for it. A further investigation of other properties thereof is planned.

Introduction

Present Practice Silica is an important raw material in the manufacture of a number of ceramic products such as porcelain, earthen ware, enamels, etc. Electrical porcelain, for instance, is usually made from clay, feldspar, and silica, the last-named forming from 15 to 25% by weight of the raw batch. Silica is commonly introduced into the raw batch either as French pebble flint, ground rock quartz, or powdered quartz sand. French pebble flint is the product formed by grinding flint pebbles found on the sea coast of France; ground rock quartz is obtained from New Hampshire, Pennsylvania, or North Carolina; and powdered quartz sand is usually made from quartz sand or sand rock from Illinois, West Virginia, or Pennsylvania.

Previous Investigations Several investigations of the properties of porcelain bodies made with different modifications of silica have been reported in the literature.[3] While many forms of silica were used in these investigations, no experiments were reported in which ground fused silica or silica glass were used as raw material,[4] although there were several reasons for supposing that such a procedure would result in bodies having desirable properties.

Thermal Expansion of Porcelain A fired electrical porcelain body consists usually of a glassy matrix in which are imbedded free quartz, crystals of mullite, and a number of finely divided inclusions which are difficult to identify. The silica which was

[1] Presented at the Annual Meeting, American Ceramic Society, Atlantic City, N. J., February 1928. (White Wares Division.) Received November 25, 1927.

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[3] Hans Hirsch, "The Effect of Various Forms of Silicic Acid on Porcelain Bodies," *Ber deut. keram. Ges.*, **7**[2], 49–87 (1926).

[4] While our experiments were in progress, announcements of the granting of Brit. 263,765 covering the use of scrap fused quartz in ceramic bodies appeared in various journals. See *Ceram. Abs.*, **6**[12], 595 (1927).

added as a raw material is only partly dissolved in the glass. The presence of free quartz tends to raise the thermal expansion of the body and, in addition, to cause irregularities in this expansion, particularly at 575°C, at which temperature crystalline quartz changes abruptly from the α to the β modification with a corresponding increase in volume. The dissolved silica, on the other hand, tends to lower the thermal expansion of the body. It can be readily seen, therefore, that the proportion of silica which dissolves, a quantity which is difficult to control, will have a very pronounced effect on the thermal expansion of the body. Bleininger[5] has estimated that a gram of dissolved silica contributes to the thermal expansion of a body only about 3% of that contributed by the same weight of silica in the form of free quartz.

Use of Fused Silica

Fused silica, as is well known, has a very low coefficient of expansion, which is generally given as 0.00000054 per degree Centigrade. If fused silica were substituted for ground quartz as a raw material in porcelain manufacture, the unsatisfactory conditions outlined in the preceding paragraph would no longer exist, as the undissolved fused silica would not raise the thermal expansion of the body, would not cause irregularities in the expansion, and the ratio between the weights of dissolved and undissolved silica would not have an important effect on the thermal expansion of the body.

Another advantage which might be derived from the use of fused silica would be a lowering of the maturing temperature of the body as fused silica dissolves in feldspar more readily than quartz. We might also expect that porcelain made from fused quartz would have a high dielectric strength and a low power factor and thus be suitable for high frequency work. Regarding other electrical and mechanical properties, little can be predicted, although it might be expected that a body made from fused silica would be more brittle than ordinary porcelain.

Sources of Fused Silica

At present a small quantity of ground fused silica is available as a by-product in the manufacture of fused silica ware. Lump fused silica has been produced at different times in the United States, although steady production has not been obtained. One large company which manufactures fused silica ware has recently advertised lump fused silica suitable for grinding for ceramic purposes. It is believed that this could be produced in large quantities at a cost that would not be prohibitive, providing the products formed from it were sufficiently superior to those made in the usual way.

[5] Chemistry in Industry, p. 100, H. E. Howe, New York, The Chemical Foundation, Inc., (1925).

Purpose of This Paper It is the purpose of this paper to give an account of some experiments of an exploratory nature which were carried out in the Ceramic Engineering Experiment Station, University of Illinois, to determine the effect of the substitution of fused silica for ground quartz sand as a raw material on the firing behavior and thermal expansion of a porcelain body.

Description of Experiments

Bodies Chosen for Investigation A body of the following composition, which we shall call Body A, was chosen as a typical electrical porcelain of the sort commonly manufactured in the United States insofar as the proportions of the ingredients were concerned.

Kentucky No. 4 ball clay	20% by weight
H. & G. A1 English china clay	30 " " "
Penn. Pulverizing Co., Buckingham feldspar	30 " " "
Ottawa (sand) flint	20 " " "

Body A was used as a "control" body for Body B, which differed from Body A only in having powdered fused silica in place of powdered Ottawa sand. The powdered fused silica was obtained by grinding scrap from the manufacture of fused silica ware. The grinding was carried out in such a way that the screen analysis of the powdered fused silica was practically the same as that of the Ottawa flint.

Preparation of Specimens A raw batch of about 6 kilograms was weighed out in the proportions given, mixed with 5 liters of distilled water, and blunged for 8 hours in a bucket blunger. The slip, so prepared, was lawned through a 120-mesh sieve, poured on a cloth-covered plaster bat, and allowed to dry to a plastic condition. The plastic material was then wedged thoroughly to remove entrapped air and used in molding standard test specimens for the determination of drying and firing behavior and also in extruding rods $1\frac{1}{4}$ inch in diameter and 10 inches long, which were used later in preparing specimens for thermal expansion measurements.

The 10-inch rods were allowed to dry in V-section wooden troughs and then their ends were ground flat in a section-cutting machine, which reduced them approximately to 9.6 inches. They were then packed in flint in V-section fireclay troughs and fired to the desired cone under conditions which will be described later. The ends of the fired rods were trued on a polishing lapp and notches for thermocouple insertion were cut at one inch from each end and at the middle of each rod.

Determination of Firing Behavior In determining the firing shrinkage and the fired porosities of Bodies A and B under various temperatures and kiln conditions, the standard test pieces,

prepared as described, were used and the Standard Methods of the AMERICAN CERAMIC SOCIETY[6] were followed. In determining the fired porosities, however, the test specimens were boiled in water under a partial vacuum and not at atmospheric pressure as prescribed in the Standards.

The volume drying shrinkage of body A was 13.5%, of the plastic volume, that of Body B was consistently lower by about 0.5%.

In a number of firings made under oxidizing conditions, it was found that Body B with fused quartz, when fired higher than cone 4, developed a vesicular structure and a dense product could not be obtained. In later work, however, it was found that if Body B was fired under

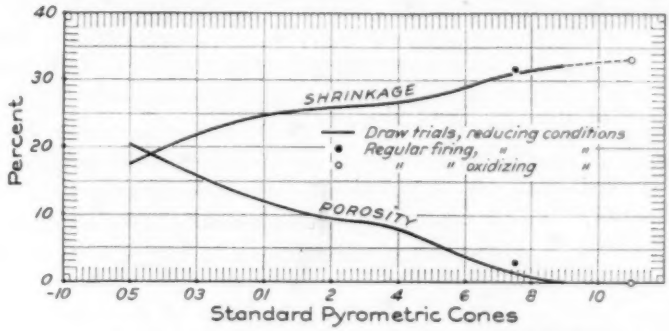

FIG. 1.—Body A (typical electrical porcelain).

slightly reducing conditions a dense product could be obtained. Figures 1 and 2 show firing shrinkage and porosity curves for Bodies A and B respectively. In Fig. 1, the full-line curves were plotted from data obtained by draw trials in firings made under slightly reducing conditions, the closed circles from data obtained by means of a regular firing under reducing conditions and the open circles from data obtained from regular firings under oxidizing conditions. It will be seen that Body A fires to a low porosity and high shrinkage when fired to cone 11 under oxidizing conditions and is not influenced greatly by being fired under reducing conditions. The same procedure was used in plotting the curves and points shown in Fig. 2, which was plotted from the data obtained with Body B. It will be seen that Body B, when fired under oxidizing conditions to cone 11 is very markedly overfired, but under reducing conditions, fires to a very low porosity from cones 5 to 8, although it does not reach a very low porosity when fired under oxidizing conditions in this range. In the regular firing under reducing conditions, the kiln was fired by oil under oxidizing conditions until the desired temperature was reached; city gas was then

[6] Year Book of the AMERICAN CERAMIC SOCIETY, 1921–22.

introduced into the burner port through an auxiliary burner in sufficient quantity to make the kiln "smoke." This was continued for an hour, during which the temperature was held constant, and then the kiln was allowed to cool under oxidizing conditions.

As a result of the experiments which have been described, it seemed reasonable to conclude that Body B differed markedly in firing behavior from Body A under oxidizing conditions, developing a vesicular structure which made it impossible to secure a dense product and, under reducing conditions, having a maturing range three or four cones lower than that of Body A.

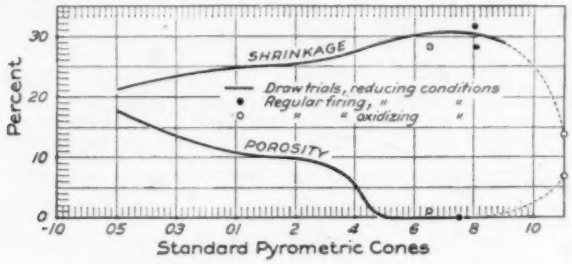

FIG. 2.—Body B (fused silica porcelain or "fusilain").

Thermal Expansion The thermal expansions of the specimens prepared as described were measured by means of an apparatus whose operating principle is shown diagrammatically in Fig. 3 and whose construction is shown in detail in Fig. 4.

Referring to Fig. 3 it will be seen that the apparatus consisted essentially of a rigid, water-cooled, metal framework (double-hatched), fused silica end-pieces (indicated by single-hatching), a dial gage, a water-cooled radiation shield, and a specimen. If the specimen were heated and the water-cooled metal parts maintained at a constant temperature, it is evident that the dial gage would register the increase in length of the specimen and of the fused-silica end-pieces, the dial itself being protected from excessive temperature changes by the radiation shield and the water-cooled cap on the upper fused silica end-piece. By using a specimen of known expansion, such as a specimen of fused silica, the thermal expansion of the end-pieces, which in our experiments amounted to about 10% of the change in length registered on the dial, could be obtained and applied as a correction in experiments with other specimens. In the same way corrections could be applied for variations in the temperature of the circulating water, which seldom exceeded 2°C in our experiments, using data obtained in experiments in which the specimen was not heated and the temperature of the circulating water was varied. That the temperature

distribution in the end-pieces corresponding to a given specimen temperature was practically independent of the rate of heating was shown by the fact that expansion curves obtained by heating the specimen at a uniform rate and those obtained by raising the specimen rapidly to given temperatures were essentially the same. This result was due to the small thermal lag in the end-pieces and to their water-cooled caps.

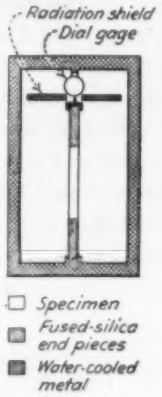

FIG. 3.—Principle of thermal expansion apparatus.

Figure 4 shows the details of the construction of the apparatus, the length of Specimen *A* being 9 inches and remainder being drawn to the same scale. A nichrome-wound furnace of a simple type was used to heat Specimen *A*, whose temperature was measured at 3 points by means of a multiple base-metal thermocouple having 3 hot junctions and a common return, the hot junctions being placed in notches cut in the specimen. End-pieces *BB* were made by sealing fused-silica disks to the ends of tubes of the same material which were filled with Sil-O-Cel and were in turn cemented to water-cooled metal caps.

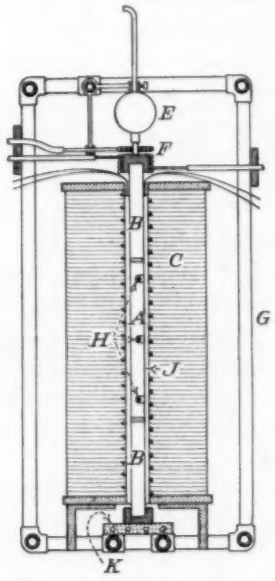

FIG. 4.—Apparatus for measuring thermal expansion.

Radiation shield *F* consisted of a flat coil of copper tubing through which water circulated. Dial gage *E*, which could be read to 0.0001 inch, was fastened securely to water-cooled frame *G*, which was a rectangular frame-work of ordinary 1-inch water pipe. The specimen, end-pieces, and caps were supported on a water-cooled brass plate *K* which was clamped to the lower part of the frame work, the furnace had no mechanical connection to the rest of the apparatus, and the space between the specimen and end-pieces and the furnace was filled with pure asbestos tape to prevent convection currents. The temperature of the specimen was taken to be the weighted average of the temperatures indicated by the multiple couple, the temperature of the junction at the middle of the specimen being assigned twice the weight of the temperatures of the other junctions. The average difference in temperature between the middle and the end junctions in our experiments was about 3°C and seldom exceeded

10°C. The lengths of the specimens at room temperature were measured by means of calipers reading to 0.01 inch. These were used in computing the per cent expansion of the different specimens.

The dial gage was calibrated by measurements made with Johannsen blocks, which showed that the average error was about 0.0002 inch with a maximum of 0.0007 inch. There were practically no systematic errors, the errors cancelling out at each complete revolution of the pointer, so that by drawing a smooth curve when the data were plotted, most of the dial errors could be eliminated. The thermocouple was correct to within 3°C, so that the only uncertainty in the measurements was that due to radial temperature gradients in the specimen, which would not be very large.

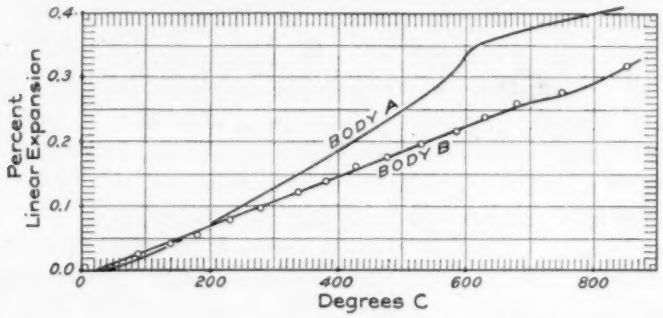

FIG. 5.—Thermal expansion curves. Body A, typical electrical porcelain fired to cone 11. Body B, fused silica porcelain or "fusilain" fired to cone 8 under reducing conditions.

The thermal expansion curves for the two bodies are shown in Fig. 5. The upper curve is the expansion curve for Body A fired to cone 11 under oxidizing conditions, the lower is that for Body B fired to cone 8 under reducing conditions as described in "Thermal Expansion."[7] It will be seen that Body A has a much higher expansion than Body B, the thermal expansion for Body A between room temperature and 800°C being about 0.40%, whereas that for Body B is about 0.29%. The curve for Body A also shows a decided jog at about 575°C whereas that for Body B does not.

Microscopic Examination

Thin sections of some of the test specimens of the two bodies were examined under a petrographic microscope. Sections cut from specimens of Body A fired to cone 2 contained angular fragments of the quartz sand which had apparently not dissolved to an appreciable extent. Sections cut from specimens fired to higher temperatures showed a denser structure and a rounding

[7] See p. 86.

of the quartz grains due to solution. A similar examination of specimens of Body B showed that, at cone 2, very little solution of the fragments of fused silica was evident. At higher temperatures these fragments became slightly birefringent. This birefringence did not appear to be due to devitrification since each fragment extinguished as a unit when the stage of the microscope was rotated. If devitrification had taken place, we would expect to find a number of small crystals arranged in random fashion in each fragment, which would not extinguish as a whole. The birefringence was probably due to mechanical stresses set up when the body was cooled. At cone 11, very small, needle-shaped crystals resembling mullite developed in the fused silica fragments, which had softened considerably. This would indicate that alumina had dissolved in the fragments. A vesicular structure was also evident.

Summary

When fired under oxidizing conditions, Body B was found to develop a vesicular structure for firing temperatures higher than cone 4 which prevented the production of a very low porosity. When fired under reducing conditions, however, Body B matured about three or four cones lower than Body A, a very dense product being obtained.

The thermal expansion of Body B when fired under reducing conditions to cone 8 was found to be much lower and more regular than that of Body A fired to cone 11 under oxidizing conditions.

A peculiar birefringence developed in the fused silica fragments in specimens of Body B fired above cone 2, and at cone 11 these fragments softened appreciably and small crystals resembling mullite appeared.

Since Body B differed so materially from Body A and since the usefulness of the word "porcelain" has already suffered from its too general application, it is suggested that bodies similar to Body B be given the name "fusilain."

The investigation of the properties of Body B or fusilain is being continued and it is planned to measure its transverse strength, resistance to impact and thermal shock, and electrical properties.

Acknowledgment The writer wishes to express his appreciation for the interest and help of C. W. Parmelee, head of Department of Ceramic Engineering, University of Illinois, and of E. F. Creevy[8] and I. W. Schoeninger, senior student in the department.

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A REVIEW OF THE LITERATURE ON LABORATORY SLAG TESTS FOR REFRACTORIES[1]

By Robert F. Ferguson[2]

ABSTRACT

A critical description is given of the numerous laboratory tests which have been proposed to determine the resistance of refractories to slag action.

Introduction

A great many attempts have been made to develop a laboratory slag test. None as yet have met with universal approval. If a small amount of slag is used, its composition will change during the test and its chemical activity is diminished, and, furthermore, no account can be taken of erosion. If a large quantity of slag is used, it is difficult to find refractory containers which are not attacked. If the slag is impinged on the refractory, it is necessary to increase the time or the temperature beyond desirable limits. If the refractory and slag are intimately mixed, only the physico-chemical effects are observed, and no account is taken of the penetration or erosion. As a guide to future work, the following summary of previous investigations is given. It is believed that this review is very nearly complete. To keep the article within reasonable length, it has been necessary to omit detailed descriptions of apparatus and results, and reference to the original literature is indicated if further particulars are desired.

The earliest effort to determine the interaction of refractory materials and slags appears to be the work of E. Cramer,[3] published in 1901. Cramer investigated the action of lime and cement on fire clay by molding cones of the fluxing material and placing them on the clay fire brick. After heating in a porcelain kiln, the temperature at which the cones collapsed was noted. A similar method was used by McDowell and Howe[4] in 1919 in testing the reaction between fireclay brick and magnesite or dolomite. Chips of fire brick were set in a pat of the basic material to be examined and the temperature determined at which there was a rapid reaction between the two materials. This method is limited to the use of fluxes which react violently and form low-melting compounds.

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[1] Received November 25, 1927. Presented at the Annual Meeting, American Ceramic Society, Atlantic City, N. J., February 5–11, 1928. (Refractories Division.)

[2] Junior Industrial Fellowship, Multiple Industrial Fellowship on Refractories (American Refractories Institute Foundation), Mellon Institute, Pittsburgh, Pa.

[3] M. Hirsch, *Sprechsaal*, **45**, 213 (1912).

[4] J. S. McDowell and R. M. Howe, *Bull. Amer. Inst. Min. Eng.*, **146**, 291 (1919); *Trans. Amer. Inst. Min. Eng.*, **62**, 90 (1919); *Blast Fur. Ste l Plant*, **7**, 227 (1919).

Slag Placed on Surface of Brick

Probably the most obvious method of examining slag action is to place some of the slag on the brick, and this method was described by Gilbert Rigg[5] in 1913. Rigg used a block of slag 3 by $1^1/_2$ by 1 inch molded with starch, and placed this on the edge of a half brick. The test brick was heated to about 100°C, above the temperature at which the brick were to be used, causing the slag to flow down the surface on three faces. The best data were secured with dense fine-grained brick. Stone[6] in 1916 employed a similar method, but used 1-inch cubes of slag and placed them on the face of the brick. Geller[7] confined the slag in a cardboard ring 2 by 1 inch high and used a temperature of 1400°C.

M. Hirsch desired to use a larger quantity of slag[3] and published a method in 1912. Five different clay mixtures, each fired to a different temperature, were used in the form of specially molded hollow blocks. The action of manganese-bearing cupola slag, Portland cement, and marble was investigated by placing the powdered slag in the pockets and firing to cone 14. After the test, when the pieces were sawed in half and the penetration measured, it appeared that the clay mixtures with the densest texture and the hardest firing had the least slag penetration.

C. W. Thomas[8] in 1917 suggested using hollow cubes and examining the slag action under a microscope.

While investigating magnesite refractories, McDowell and Howe[4] in 1919 used a crucible molded of the basic refractory and filled with a corrosive mixture consisting of 1 part ferrophosphide and 2 parts ferric oxide. At the conclusion of the heat treatment the slag was analyzed for silica, lime, and magnesia.

In an effort to standardize the slag test, Nesbitt and Bell[9] in 1916 described a method of drilling cavities in the brick for the purpose of retaining the slag. This was accomplished by using a steel drill of fish-tail design $^5/_{16}$ inch thick, and precautions were taken to insure drilling a hole $2^1/_2$ inches in diameter and $^1/_2$ inch deep at the sides. Brick with two cavities were placed in a furnace and heated to 1350°C in 6 hours, when 35 grams of powdered slag were placed in each pocket, and the temperature held for two hours. When cold, the brick were sawed in half and the slag penetration measured with a planimeter. A basic open-hearth and a heating-furnace slag of definite compositions

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[5] G. Rigg, *Jour. Soc. Chem. Ind.*, **33,** 623 (1914); *Ind Eng. Chem.*, **5,** 549 (1913).
[6] Stone, *Proc. A.S.T.M.*, **16,** 374 (1916).
[7] R. F. Geller, *Jour. Amer. Ceram. Soc.*, **7** [9], 663 (1924).
[8] C. W. Thomas, *Trans. Ceram. Soc.* [Eng.], **17,** 102 (1917).
[9] C. E. Nesbitt and M. L. Bell, *Proc. A.S.T.M.*, **16,** 350 (1916).

were used. On the basis of this method, the denser brick were found to show the least slag penetration. Further details of the method were published by the same authors[10] in 1916 and 1917. It was found that the degree of fineness of the slag did not affect the penetration nor did longer heating or increased quantities of slag.

The cavity method[11] was issued by the A.S.T.M. as a tentative standard in 1917 and was modified in 1919 when it was prescribed that rings be cemented onto the face of the brick in order not to destroy the natural surface.[12] A.S.T.M. tentative standard C17–19T gives complete details for synthesizing the slag and making the rings and cement. This test[13] was subsequently withdrawn in 1925.

R. L. Johnson[14] in 1919 used the cavity and ring methods in examining the action of frits, but favored the latter and in the same year the committee on tests for the English Ceramic Society[15] endorsed the ring method. Peters[16] in 1922 used the ring method and a synthetic slag in testing various clay-bonded silicon-carbide brick. The penetration was small and difficult to measure and the results were somewhat uncertain.

H. Hirsch[17] in 1923 used the ring method in investigating the action of 8 different slags on 7 different brick, both brick and slag having a wide range of composition. The results showed that the penetration depended primarily on the porosity and contrary to expectation, the chemical composition made little difference. This discrepancy was especially noticed in the case of the calcareous and ferruginous ashes which were expected readily to attack the siliceous brick. J. H. Gill[18] used the penetration method for testing mullite brick and found no penetration.

Howe[19] was of the opinion that the slag penetration test measured nothing but the structure of the brick, and based his conclusion on the following observations: (1) penetration is not a function of the time; (2) brick often show a large penetration and are yet chemically unaffected; (3) the plastic clay content of the brick controls the penetra-

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[10] C. E. Nesbitt and M. L. Bell, *Met. Chem. Eng.*, **15,** 205 (1916); *Brick Clay Rec.*, **51,** 518 (1917).

[11] *Proc. A.S.T.M.*, **17,** 669 (1917).

[12] *Ibid.*, **19,** 586 (1919).

[13] *Ibid.*, **25,** 190 (1925).

[14] R. L. Johnson, *Pottery Gaz.*, **44,** 489 (1919); abstracted in *Jour. Amer. Ceram. Soc.*, **2** [10], 841 (1919).

[15] Cobb and others, *Trans. Ceram. Soc.* [Eng.], **18,** 516 (1919).

[16] M. F. Peters, *Jour. Amer. Ceram. Soc.*, **5** [4], 188 (1922).

[17] H. Hirsch, *Tonind. Ztg.*, **47,** 152 (1923); *Keram. Rund.*, **31** (1923).

[18] J. H. Gill, *Ceram. Ind.*, **8,** 47 (1927).

[19] R. M. Howe, *Brick Clay Rec.*, **53,** 1066 (1918).

tion; (4) dense siliceous brick show a lower penetration than special slag-resisting brick even with a basic slag. Howe experimented with the use of viscous sugar solutions colored with a green dye and obtained practically the same results as are secured by the slag-penetration test. Such a test could be standardized and manipulated more easily than the slag-penetration test and was suggested by Howe as a substitute for determining this property.

Further work by the same author in 1919 showed that the slag action is more severe at higher temperatures.[20]

In 1923, Howe[21] made a critical study of the ring slag test, at that time a tentative standard. Seven different metallurgical slags were applied against 3 brick from different districts, and the influencing factors were each varied while other conditions were held constant. It was found that, after 2 hours, the slag penetration was independent of the time, was not influenced by the quantity of slag, and was but slightly influenced by increasing both slag and time. Furnace atmosphere had considerable influence, reducing atmosphere favoring penetration of heating furnace slag, but retarding the penetration of copper oxide. There was no relation found between temperature and penetration, although from 1150 to 1350°C there was an increase in penetration with increasing temperature. The most serious criticism of the test, found by this study, was that there was no distinction made between penetration and chemical action. Cases where the slag had obviously corroded the brick gave no higher results than where it was seen that there was a simple penetration devoid of chemical action. From the foregoing,Howe concluded that of the two factors penetration is the less important, because, while penetrating, the slag becomes cold and viscous and its chemical activity decreases rapidly as it leaves the surface. At another time in the same year, Howe[22] discussed the methods of Brown, Nesbitt and Bell, and Fischer, and stated that the method of Fischer appeared to be the most simple and practical.

The fact that slag action is the result of two factors, penetration of the pores of the brick and chemical solution of the material, was recognized by G. H. Brown.[23] He objected to both the ring and the cavity method because the quantity of slag was so small that its composition would change during the test and because not enough area of the brick was exposed to the slag. He therefore used fireclay boxes in which the brick to be tested were placed on edge and firmly packed on two sides with finely ground slag. They were then heated to 1400°C

[20] R. M. Howe, *Brick Clay Rec.*, **54,** 143 (1919).
[21] R. M. Howe, *Jour. Amer. Ceram. Soc.*, **6** [1], 296 (1923).
[22] R. M. Howe, *Ibid.*, **6** [2], 466 (1923).
[23] G. H. Brown, *Trans. Amer. Ceram. Soc* , **18,** 2 (1916).

over a period of 36 hours, after which the boxes were broken in half and examined. A corrosive coal ash was used for the slag and 24 brands of brick, including magnesite, silica, and silicon-carbide, were tested. The advantages claimed for this test are that a considerable portion of the brick is exposed to the test and a large quantity of slag can be used.

H. B. Cronshaw[24] in 1917 felt that a distinction should be made between porosity and slag penetration, and suggested immersing a cube of fire brick in a bath of molten slag and determining the porosity before and after immersion.

Refractory Immersed in Slag

In all the foregoing tests, a relatively small amount of slag was used in connection with a relatively large amount of refractory. A test in which the conditions were reversed was used by E. A. Coad-Pryor[25] in 1918 in studying the action of glass batches on refractories. Rods of refractory material were immersed in pots holding 100 grams of melted glass and the desired temperature maintained in an electric furnace. The rods took on a taper form so that it was impossible to express the results quantitatively. It was found that the effects of porosity were less than had been expected. Walter Rosenhain[26] continued the work of Coad-Pryor.

Chas. I. Rose[27] in 1923 modified the above by slowly rotating the rod during the test. This accelerated the test and took into account the effect of abrasion by the moving glass batch. He also made the results quantitative by annealing the rod when it was withdrawn, and then cutting it in half and measuring the slag penetration with a low-powered microscope. The results were expressed in inches of erosion per day. The following advantages are claimed for this method: (1) solution and penetration can be easily distinguished and accurately measured, (2) it gives quantitative results, (3) simple apparatus is employed, (4) the characteristics of the refractory are not destroyed before or during the test, and (5) it permits a wide variation of conditions which may be fixed as desired.

Recently, Parmelee[28] has reversed the process insofar as he rotates the furnace, the walls of which are constructed of the brick under test.

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[24] H. B. Cronshaw, *Trans. Faraday Soc.*, **12,** 252 (1917).
[25] E. A. Coad-Pryor, *Jour. Soc. Glass Tech.*, **2,** 285 (1918).
[26] Walter Rosenhain, *Jour. Soc. Glass Tech.*, **3,** 93 (1919).
[27] Charles I. Rose, *Jour. Amer. Ceram. Soc.*, **6** [11], 1242 (1923).
[28] C. W. Parmelee, to be published in *Jour. Amer. Ceram. Soc.*

Impinging Slag upon Refractory

In any test in which the slag is placed in contact with the refractory, a limited amount of slag must be used, and the composition is continually changing due to solution of the refractory. In order to have a constantly renewing slag supply, Mellor and Emery[29] constructed a furnace in which two bricks were laid flat on the hearth and a flame impinged on them from above. Slag was fed regularly into the burner pipe and traveled with the flame to the brick. These investigators used eight different flue dusts and temperatures of 1100, 1200, 1300, and 1400°C. At temperatures below 1300° they concluded that the action is mechanical rather than chemical and limited their later experiments to 1400°C. Three silica bricks and two fireclay bricks were tested, but it was not found possible to express the results quantitatively, so photographs were used.

F. H. Norton[30] tried dipping the brick in a bath of molten slag, withdrawing, allowing to drain off, and then repeating the process until the brick was reduced in size. This method was unsuccessful because no container could be found to hold the slag at high temperatures without serious contamination and because the specimens did not have the required strength to support themselves when being removed from the slag.

Norton therefore attempted to introduce the slag through the burner in a method similar to that used by Mellor and Emery. Test pieces in the form of one-inch cubes were used and their volume measured by sand displacement before and after the test. Six brick, including fireclay, bauxite, silicon carbide, and magnesite, were tested with a coal ash at temperatures ranging from 1260 to 1740°C. It was found that the action was largely dependent on temperature and that the brick withstood the effects of increased temperatures in different order. The chief advantages claimed for this method are that the test can be run rapidly and at high temperatures and that the results agree with service.

An adaptation of the impingement method was used by R. F. Geller.[31] The brick to be tested were built in the form of a small chamber inside a larger kiln and a temperature of 1450°C maintained for one and one-half hours. Slag was introduced through a refractory tube in the roof and carried by the flame against the test wall. The results were not sufficiently pronounced to warrant conclusions, but indicated that valuable information could be secured by prolonging the test a sufficient

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[29] J. W. Mellor and W. Emery, *Trans. Ceram. Soc.* [Eng.], **18**, 230 (1918).
[30] F. H. Norton, *Jour. Amer. Ceram. Soc.*, **7** [8], 599 (1924).
[31] R. F. Geller, Bur. Stand , *Tech. Paper*, No. 279 (1925).

length of time. M. L. Freed[32] used the same method in testing mullite brick and continued the test four hours.

F. Hartmann[33] has recently adapted the impingement method to the use of less expensive apparatus. Test pieces 30 mm. in diameter and 30 mm. high are placed in the middle of a vertical carbon resistance furnace, and, at operating temperatures slightly above the melting point of the slag, 40 grams of slag are fed through a quartz-glass funnel over a period of 30 minutes. A mercury volumeter is employed for measuring the volume of the test pieces before and after treatment.

A means of testing whole brick has been devised by G. B. Wilkes and described by E. B. Powell.[34] In the end of the brick is cut a sloping trough which serves to hold the slag until it is melted and to direct the flow of the molten slag down on the edge of the brick. The brick are set on end in a furnace which is operated at 1482°C, and the slag is fed into the trough through an alundum tube.

A test which simulates service conditions has been devised by engineers of the West Penn Power Company and is described by Hankinson.[35] A square furnace is used which consists essentially of four hollow piers. Between the piers panels of the test brick are built sloping at an angle of 15° from the vertical, and these piers form the four walls of the furnace. A roof is sprung from the panels and the panels held firm by means of a spring. Small Dutch ovens on the roof hold the slag until it melts and flows down over the panels. A temperature of 1650°C is maintained for 18 hours, during which time 25 pounds of slag are added by increments to each panel. The test has the disadvantage of being costly and of not permitting quantitative results.

In Germany a furnace to simulate service conditions has recently been devised by Kroll and Steinhoff and described by E. H. Schulz.[36] This is similar to a small metallurgical furnace capable of maintaining a temperature of 1650°C for weeks at a time. The slag is charged upon a bowl-shaped hearth.

The Cone Method

All of the methods which have been proposed and described in the preceding paragraphs have depended on bringing the refractories and slags together in a gross way and determining the ultimate results.

[32] M. L. Freed, *Jour. Amer. Ceram. Soc.*, **9** [5], 255 (1926).

[33] F. Hartman, *Ber Werkstoffsaussch ver. deut. Eisenhüttenleite*, **81** (1926); *Stahl u. Eisen*, **47**, 182 (1927); *Ceram. Abs.*, **6** [5], 178 (1927).

[34] E. B. Powell, *Trans. A.S.M.E.*, **47**, 881 (1925); *Power*, **62**, 894 (1925); Testing Materials for Refractories, Stone and Webster, Inc.

[35] Hankinson, *Trans. A.S.M.E.*, **47**, 931 (1925); see also footnote 36.

[36] Schulz, *Stahl u. Eisen*, **45** [1733], 1777 (1925).

As early as 1912, however, W. Stout[37] showed that slag when acting on a fire brick formed new compounds and that the softening temperature of these compounds determine the ability of the brick to withstand slag action. A method which takes into consideration this principle and which is a radical departure from other methods was used by Mellor[38] in 1913. In order to determine the effect of flue dust on refractories, the dust was mixed with samples of the ground brick and the mixture molded into cones. The softening-point of the cones was then determined. Fischer[39] in 1920, while selecting brick for boiler service, resorted to the same method. Mixtures of coal ash and fire brick in 1:1 ratios were used for the cones and the softening points determined in a Deville furnace. When the softening temperature of the 1:1 mixture was below the arithmetical mean of that of the two components, Fischer considered the fluxing action too severe and regarded the brick as unsuited for use against that slag. A few mixtures were obtained which showed a softening temperature above the mean, and the author regarded this method as very promising for selecting both brick and coals.

This cone mixture method was further studied by Howe, Phelps, and Ferguson[40] in 1923. They used magnesite, chrome, diaspore, and five kinds of clay brick, mixed with five different metallurgical slags, in batches containing 4, 8, 12, 16, 20, 30, 40, and 50% slag. When the cone equivalents of the different mixtures were determined, it was seen that there was a relation between the lowering of the cone equivalent and the composition of the brick, the nature of the slag and the concentration of the slag. The work of these authors was reviewed in France by Gilard.[41]

Brennan[42] made further use of the method in 1924 and mixed 70% ground brick with 30% coal ash. He reported that the history of the brick in service agreed closely with the indications given in the test. Wilson, Sims, and Schroeder[43] mixed 15% slag with sillimanite, silicon-carbide, silica, alundum, and zirkite brick. They found the cone-fusion method to be an excellent way of determining the chemical activity of the slag in contact with the refractory, but used a bath test in addition to distinguish between the structural properties of the refractories.

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[37] W. Stout, *Trans. Amer. Ceram. Soc.*, **14,** 252 (1912).

[38] J. W. Mellor, *Trans. Ceram. Soc.* [Eng.], **13,** 12 (1913).

[39] Fischer, *Combustion*, **2,** 12 (1920).

[40] R. M. Howe, S. M. Phelps, and R. F. Ferguson, *Jour. Amer. Ceram. Soc.*, **6** [4], 589 (1923); R. F. Ferguson, *Bull. Amer. Ceram. Soc.*, **2** [9], 307 (1923).

[41] P. Gilard, *Rev. universelle mines*, **18,** 315 (1924).

[42] J. J. Brennan, *Combustion*, **10,** 418 (1924).

[43] H. Wilson, C. E. Sims, and F. W. Schroeder, *Jour. Amer. Ceram. Soc.*, **7** [12], 910 (1924).

Geller[7] measured the resistance of aluminous refractories to cement clinker by fusing mixtures of equal weights of brick and clinker. Likewise, Kohlmeyer[44] selected brick for high-duty boiler service in the same way, fusing cones containing 4, 8, 12, 16 and 20% ash. Booze and Flint[45] investigated a service test for checker brick for a glass-melting tank. At the conclusion of the service test, the various brick were mixed with 5, 10, and 20% of the dust to which they had been exposed and the cone equivalents determined. It was found that there was a general agreement between the amount of erosion in service and the cone equivalents of the slag-brick mixtures. Booze also made use of this method in investigating brick for use in open-hearth checkers and employed a 25% slag mixture.[46]

Hewitt[47] in 1926 investigated the merits of the cone-slag test. He departed from the previous work by using mixtures in which the slag was the predominating ingredient. This approached more closely to conditions encountered in service, but introduced a number of variable factors which were difficult to control.

H. S. Houldsworth[48] used cones containing 10 and 15% glass cullet in studying the properties of clay-bonded sillimanite brick. Fritz Ilgen[49] in 1926 mixed blast-furnace dust with various refractories in ratios ranging up to equal proportions.

Other methods of limited application have been proposed. H. V. Thompson[50] used a porcelain cylinder wound with nichrome wire and heated to 1100°C. Chips of the material to be examined were placed in the tube and a stream of sodium chloride vapor passed over. Donald Turner[51] submitted the ground grog in a nickel crucible to the action of the alkali salts used in glass making. At the end of the heat treatment the grog was washed in acid and water and the loss in weight determined. Firth, Hodkin, and Turner continued these investigations.[52] S. English[53] held molten glass for a long time in pots of different materials and analyzed the glass afterwards for iron and alumina.

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[44] F. A. Kohlmeyer, *Jour. Amer. Ceram. Soc.*, **8** [5], 317 (1925); Detroit Edison Co. *Proc. N.E.L.A.*, **81**, 1328 (1924).

[45] M. C. Booze and F. C. Flint, *Jour. Amer. Ceram. Soc.*, **7** [8], 596 (1924).

[46] M. C. Booze, *Jour. Amer. Ceram. Soc.*, **7** [9], 686 (1924).

[47] L. C. Hewitt, *Jour. Amer. Ceram. Soc.*, **9** [9], 575 (1926).

[48] H. S. Houldsworth, *Trans. Ceram. Soc.* [Eng.], **24**, 33 (1924).

[49] Fritz Illgen, *Ber. deut. keram. Ges.*, **7**, 32 (1926).

[50] H. V. Thompson, *Trans. Ceram. Soc.* [Eng.], **17**, 340 (1917).

[51] Donald Turner, *Jour. Soc. Glass Tech.*, **7**, 207 (1923).

[52] E. M. Firth, F. W. Hodkin, and W. E. S. Turner, *Jour. Soc. Glass Tech.*, **7**, 228 (1923).

[53] S. English, *Jour. Soc. Glass Tech.*, **7**, 253 (1923).

NOTES ON A METHOD FOR DETERMINATION OF WORKABILITY OF PLASTIC CLAYS

By Samuel J. McDowell[1]

ABSTRACT

A factory control test is described for determining the point at which workable plasticity is developed.

Introduction

In most clay industries a portion of the products is formed in the plastic state and it is highly desirable that a uniform workability be maintained to insure correct forming properties as well as freedom from warpage and cracking of the finished pieces. This is especially true in terra cotta and other ware which are pressed plastic into molds and in which "hard" clay in one end and "soft" clay in the other end of a piece would give rise to tremendous strains, resulting in warping or cracking in the drying or firing.

Fig. 1.

Proper working consistency is somewhat difficult to determine by feeling the material. Clay with exactly the same water content may one day be classed by the same person as slightly hard and the next day as satisfactory. Bole[2] points out the unreliability of this human factor in relative plasticity determinations. His results are equally applicable to degrees of workability of the same body. It is therefore desirable to develop a test which will mechanically evaluate this property.

Review of Literature

Most of the early investigations reviewed were attempts to determine the plasticity of clays by simple tests but what actually was measured was workability. The tests which seemed most logical were: (*a*) some stage in clay consistency as determined by Atterberg[3] or by Kinnison;[4] (*b*) an extrusion method similar to Bischof,[5] (*c*) the extension method of Zschokke,[6] and (*d*) some method of compressibility. The latter seemed most interesting and has

[1] Corning Terra Cotta Co., Inc., Corning, N. Y. Received June 30, 1927.

[2] G. A. Bole, "Mechanism of Plasticity from a Colloid Standpoint," *Jour. Amer. Ceram. Soc.*, **5**, 469 (1922).

[3] Atterberg, 1911.

[4] C. S. Kinnison, "A Study of the Atterberg Plasticity Method," *Trans. Amer. Ceram. Soc.*, **16**, 472 (1914).

[5] Die Feuerfesten Thone, 84.

[6] Searle, Chemistry and Physics of Clays, p. 279.

been used in some form by Ackermann,[7] Stringer and Emery,[8] W. E. Emley,[9] and others, and from their recorded observations it was concluded that some compressibility test would be the simplest and best.

The Apparatus

The apparatus used is shown in Fig. 1 with a 2-inch cubical test piece in place at *B*. A weight of 8000 grams was applied vertically to the upper movable plate, while the lower plate was kept in a stationary position and the amount of distance that the cube was deformed under compression was recorded on the scale at *A*. The apparatus was designed for factory control and was ruggedly built. The guides and plates were bronze while the rest of the apparatus was built of steel.

FIG. 2.

Use of the Apparatus

English china clay MWM and Kentucky ball clay Old Mine No. 4 are well known and it was felt that tests of these would show what such an apparatus would do with clays of different physical properties. These two clays were thoroughly hand-wedged to what was thought to be the proper workability and a cube was made in a bronze mold and placed on the bottom plate (Fig. 1). The upper plate and attached weight was then slowly lowered without impact, until the weight rested on the clay cube and deformed it as shown in Fig. 2. After 30 seconds[10] the resulting height of the cube was measured.

To study the variations in determinations made by "feel" and by this apparatus, two persons daily for five days separately made up five bars of two clays (1) MWM English china clay and (2) Kentucky ball clay No. 4. An attempt was made by each to maintain correct workability by "feel." The same clays were also made up daily and their workability brought to a uniform standard by means of the apparatus.

	Original height of clay	Resulting height after exposure to weight of 8000 grams for 30 seconds
English china clay	1-in. cube	$^{9}/_{16} \pm {}^{1}/_{64}$ in.
Kentucky ball clay	1-in. "	$^{1}/_{2} \pm {}^{1}/_{64}$ "

[7] Searle, Chemistry and Physics of Clays, p. 279.

[8] *Trans. Ceram. Soc.* [Eng.], **21**, 93 (1921–22).

[9] *Trans. Amer. Ceram. Soc.*, **19**, 523 (1917).

[10] This arbitrary time was used because with some clays, particularly ball clays which were somewhat soft, there was a tendency for the clay to continue deforming.

All workability determinations were checked at least once. In each case the wetted clay stood overnight and was made into bars and handled according to the procedure outlined in the *Year Book of the American Ceramic Society, 1922.*

Results

TABLE I

KENTUCKY BALL CLAY

Day	Per cent water of plasticity			Per cent volume shrinkage		
	By "feel" A	By "feel" B	By workability test	By "feel" A	By "feel" B	By workability test
1	43.8	41.4	41.9	36.5	33.0	35.6
2	43.5	40.	41.5	36.2	32.0	35.0
3	42.7	40.5	41.5	35.5	33.5	33.2
4	41.1	39.9	42.0	33.8	32.3	35.1
5	40.4	38.9	42.4	32.0	31.7	35.6
Average	42.3	40.1	41.9	34.8	32.5	34.9
*Variation	1.5	1.3	.5	1.7	1.0	.7
** "	1.9	1.2	.4	2.8	.8	1.7

Day	Per cent shrinkage water			Per cent pore water		
	By "feel" A	By "feel" B	By workability test	By "feel" A	By "feel" B	By workability test
1	22.3	20.1	21.7	21.5	21.3	20.2
2	22.0	19.5	21.3	21.5	20.5	20.2
3	21.6	20.0	20.3	21.1	20.5	21.2
4	20.4	19.2	21.5	20.7	20.7	20.5
5	19.2	18.8	22.0	21.2	20.1	20.4
Average	21.1	19.5	21.4	21.2	20.6	20.5
*Variation	1.2	.6	.6	.3	.7	.7
** "	1.9	.7	1.1	.5	.5	.3

"A" and "B" denote different operators
* Above average
** Below average

TABLE II

ENGLISH CHINA CLAY

Day	Per cent water of plasticity			Per cent volume shrinkage		
	By "feel" A	By "feel" B	By workability test	By "feel" A	By "feel" B	By workability test
1	37.8	35.7	36.9	16.0	16.9	18.2
2	37.4	35.2	36.5	17.6	14.4	17.0
3	37.8	34.0	37.3	15.4	14.2	15.7
4	36.2	34.0	36.8	15.4	12.1	17.6
5	37.1	35.0	37.5	15.5	17.1	16.1
Average	37.3	34.9	37.0	16.0	14.9	16.9
*Variation	.5	.8	.5	1.6	2.2	1.3
** Variation	1.1	.9	.5	.6	2.8	1.2

Day	Per cent shrinkage water			Per cent pore water		
	By "feel" A	By "feel" B	By workability test	By "feel" A	By "feel" B	By workability test
1	10.4	10.8	11.8	27.4	24.9	25.1
2	11.3	9.2	11.1	26.1	26.0	25.4
3	10.0	9.0	10.3	27.8	25.0	27.0
4	9.9	7.7	11.5	26.3	26.3	25.3
5	10.0	10.7	10.8	27.1	24.8	26.7
Average	10.3	9.5	11.1	26.9	25.4	25.9
*Variation	1.0	.5	.7	.9	.9	1.1
** "	.4	1.3	.8	.8	.6	.6

"A" and "B" denote different operators
* Above average
** Below average

These results showed that closer checks were obtained by the use of the machine than by either operator by the "feel" method. It also showed that there was a marked difference in judgment of different men as to proper workability by the "feel" method.

Factory Application

Having shown that workability could be held within close limits in the laboratory the apparatus was immediately adapted to the factory as a check on the various platforms of terra cotta body delivered to the pressers. Each platform body which had been aged in a storage room was tested each morning. If the body fell within the limits prescribed, an O.K. ticket was placed on it for delivery to the presser that day. If the deformation was beyond the set limits, the load of clay was returned to the pug mill for retempering.

It was found that a 1-inch cube was too small. A 2-inch cube was substituted and was adopted as a standard.

The correct amount for a 2-inch cube to deform with one particular terra cotta body was between $^5/_8$ and $^{13}/_{16}$ inch or to a final height of between $1^3/_{16}$ and $1^3/_8$ inches. If the 2-inch cube deformed less than $^5/_8$ inch this load was returned as being too hard, and if more than $^{13}/_{16}$ inch it was too soft. Any material falling between these limits worked satisfactorily. The difference in water content for the terra cotta body between these limits was as follows:

Original height (inches)	Final height (inches)	Water of plasticity (per cent)
2	$1^3/_{16}$	25.5
2	$1^3/_8$	23.3

Conclusion

The above results indicate that with such an apparatus a better check could be maintained on the workability of plastic clays than by the "feel" method and more uniform manufacturing conditions maintained. By its use much of the dissatisfaction among the pressers was eliminated and closer control of warpage difficulties resulted.

A WARPAGE STUDY OF TERRA COTTA CLAYS[1]

By R. M. Murphy

ABSTRACT

Several types of clays, which compose a commercial terra cotta body, were studied for warpage during drying and firing. Results of warpage test show properties that each clay gives to the terra cotta body.

Introduction

Our terra cotta body, like most of the eastern ones, is composed of several types of clays. This fact, in itself, is a good feature, in that too much reliance is not placed on the uniformity of any one clay; but on the other hand, there is a problem to determine the proper proportion of each clay for a body of maximum quality. An individual warpage test on each of the clays gave some information on this subject and a basis from which to work in order to obtain a body of low resistance to drying and firing warpage.

Table I

Clays Tested at Cone 7

Clay	Dry shrinkage %	Total shrinkage %	Absorption %
1. Pa. fire clay (coarse grained, nonplastic)	3.5	8.1	6.1
2. Pa. fire clay (coarse grained, slightly plastic)	4.1	9.3	5.0
3. N. J. fire clay (sandy, slightly plastic)	4.7	8.1	11.6
4. Md. fire clay (highly plastic)	7.0	12.5	4.8
5. N. J. fire clay (highly plastic)	5.5	13.5	2.8

Method of Testing

Clay samples were taken from two-ton batches, which had been ground in a commercial dry pan and screened through a 12-mesh screen. All clays were proportioned by weight with 33% sagger grog; then pugged with water, and made into test bars. Dry screen analysis of grog:

10-mesh,	%	retained	4.6
20 "	"	"	51.8
40 "	"	"	22.2
60 "	"	"	8.8
80 "	"	"	7.0
100 "	"	"	3.0
100 "	"	passed	2.4

Dry warpage readings were obtained from clay bars, 9 by 1 by 1 inch, in a direction parallel to the pressing of the bar in the mold, the distance from the chord of the warpage arc to the center of the arc on the clay bars representing the amount of warpage.

Fire warpage readings were obtained from the same bars, which were

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February 1927. (Terra Cotta Division.)

suspended during firing over a 7-inch span in a position at right angles to the direction of forming in the mold.

The other properties, dry linear shrinkage, total linear shrinkage, and absorption, were determined from tests 7 by 1 by 1 inch. Shrinkage in all cases was computed on a wet basis.

TABLE II

RESULTS OF TESTS AT CONE 7

	Clays 33% grog (by weight)					
	Dry warpage (inches)	Fire warpage (inches)	Dry shrinkage %	Total shrinkage %	Fire shrinkage %	Absorption %
Clay 1*	0.0375	0.125	2.75	6.0	3.25	13.3
Clay 2	0.028	0.081	3.5	7.0	3.5	11.1
Clay 3	0.050	0.038	3.85	6.0	2.15	14.9
Clay 4	0.097	0.034	5.95	10.05	4.10	13.4
Clay 5	0.091	0.069	5.9	9.5	3.6	8.4

* Clays correspond to Table I.

Discussion of Results

Table II shows that the clays of low plasticity have a lower dry warpage but on the other hand have a higher warpage during firing than the plastic clays. This condition is true in the case of Clays 1 and 2, both of which possess little or no plasticity. Clay 3, sandy and of slight plasticity, is an exception to the other nonplastic clays, due to the fact that this clay contains about 16% of 200-mesh sand, which acts as a reinforcement to the clay structure during firing.

The highly plastic clays, 4 and 5, have a higher dry warpage, due to greater dry shrinkage than the clays of low plasticity, but on the other hand, these plastic clays have fairly low fire warpage, along with higher fire shrinkage, than the other clays.

Conclusions

In accordance with the clays tested, the following conditions are apparent:

(1) Clays of little or no plasticity are valuable in a terra cotta body as a means of reducing drying shrinkage and warpage.

(2) A sandy clay may be an important ingredient in the terra cotta batch for the production of ware free from firing warpage and firing cracks, because of the low firing warpage and shrinkage which a moderate amount of this clay imparts to the batch.

(3) Clays of high plasticity have high dry shrinkage and warpage, but these undesirable properties are compensated for by the tight firing quality and the strength to resist firing warpage, which these clays give to the batch.

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LENGTH OF TIME OF DIE USE AS AFFECTING SIZE OF FLOOR TILE[1]

By Roland V. Tailby

ABSTRACT

A description of a factory investigation to determine the practical life of dies used in pressing one-inch hexagonal tile.

Introduction

In the dust-press process of manufacturing ceramic articles, such as floor and wall tile, the abrasive materials in the body mix affect the size of dies used in pressing. It was the object of this shop investigation to determine the effect of change in die size, due to wear, on the finished size of one-inch hexagonal floor tile, and to make recommendations regarding shop standards pertaining to length of time of die use. This investigation was conducted on floor tile bodies and the dies used in their manufacture.

Body Materials

The body in use corresponded approximately to 32% clay, 13% flint, and 55% feldspar.

The clay content was made up of English china clay, Florida kaolin, and a Tennessee ball clay.

The flint used was a domestic sand flint of very high purity.

The types of feldspar used during the course of this investigation were Maine, Canadian, Connecticut, and New York. These were used in various combinations consistent with factory routine and the regular production schedule over a period of months; since there was no great difference between the results obtained for the different feldspars on preliminary tests, the problem resolved itself into determining the life of the dies with the regular body in production, using a Maine and a New York feldspar as body constituents.

Procedure

The tile tested were manufactured in the usual manner. The body was brought to the pressers in dust form, containing 8% moisture. Crossley machine presses, with steel cap and plungers and soft chill cast-iron case were used. The cap and plungers were case-hardened special steel, containing .20% carbon and .25% manganese.

It was a recognized fact, before this test was begun, that the tile size variation, as affected by differences in die filling, was a factor which must be contended with in regulating a constant size of finished ware.

[1] Received November 12, 1927. Presented at the Annual Meeting, American Ceramic Society, Atlantic City, N. J., February 1928. (White Wares Division.)

It was accordingly decided to run a separate investigation to attempt to determine and regulate this difference.

One-inch hexagonal tile were secured from the front and rear of each die, pressed under different conditions, such as having filler half full of dust or full of dust, and bumping filler against front of die, one, two, and three times. These tile were weighed and compared for size in the green and fired state.

It was found that there was a difference in weight of tile pressed in the front and rear of each die by as much as 25 grains in some cases. These checked exactly for thickness and overall size in the green state but those weighing the least while green were smallest after firing.

The pressers were instructed as to the purpose of this test, and informed of the proper method of filling the dies. Tile were taken daily from each presser and weighed; this procedure was continued about two weeks, after which their full coöperation was obtained.

The weights of the one-inch hexagonal tile were found to run more uniform, and the difference in weight between the tile from the front and rear of the dies was cut from a maximum of 25 grains to a maximum of 10 grains without exception.

After new dies and cases were placed on each machine and carefully lined up, a record was made of the die number, presser's name, date of starting the die, and general remarks. After this, one sagger was taken from each presser every fifth day, marked, and a record kept of the total number of saggers pressed on the die up to the time of taking the sample. These saggers were marked, and fired together in the same kiln after each die had pressed 4200 saggers. Samples of fired tile were taken from each sagger and those tile which were pressed on the same machine were compared for size from the time the test started until it was completed.

After 3780 saggers each containing 8 square feet of tile were pressed, it was found that the tile size began to increase rapidly so that by the time 4060 saggers, or 32,480 square feet, had been pressed, the tile were running too thick and from $1/32$ to $3/64$ inch oversize, after firing. This gave considerable trouble in the pasting room in that many of the tile would not fit into the pasting boards, or once in stuck too tightly, causing a general slowing up of work.

It was accordingly decided from the results of this investigation that each die should be replaced after 3700 saggers (29,600 square feet of 1 inch hexagonal tile) have been pressed.

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POSSIBLE FUTURE USES OF CLAYS[1]

By W. A. Koehler

ABSTRACT

The need for investigation of new uses for clays which may become necessary if brick are substituted for by new materials is stressed. The shortcomings of brick, and possible new methods of clay processing are enumerated.

Introduction

Brick making is one of the oldest of the industries and has withstood competition for more than 6000 years. New materials have been substituted for brick, yet the brick industry seems entrenched as firmly as ever.

Yet with all this apparent security, those interested must, in this present day of revolutionary industrial ideas, come to a realization that clay brick so long secure may possibly by new inventions become obsolete, and that the manufacturer of fired clay ware may in a short time find himself confronted by the same problem as was the carriage maker and blacksmith of but little more than a decade ago.

It is therefore necessary for those interested in the utilization of clay to keep alert, not only to the continued production of clay ware by present-day methods, but also to extension by new methods and processes. This would resolve itself into several aspects: (1) A protection of the brick industry since it uses about 30% of the value of clay utilized in the United States. This would require, in part, continued and extended education of the public to the utilitarian value and beauty of brick as a structural material. (2) Reduction in the manufacturing cost of fired clay ware. (3) Reduction in the cost of construction with this ware. (4) Research in new methods of utilizing clay. This last topic is of chief interest to this paper.

Shortcomings of Brick

With all the advantages of fired clay wares, the products have a number of shortcomings which may be summed up as follows: (1) the ware cannot be turned out true to dimensions and shape, (2) the reshaping of fired clay ware is slow and costly, (3) their brittleness is a decided disadvantage for many purposes, (4) the initial cost of building with brick is higher than that for a number of other structural materials, and (5) the waste in in the process of manufacture is very large.

We are so accustomed to the well-known properties of fired clay ware, that they are taken for granted without inquiring if possibly the clay cannot be processed in some modified or radically new way that would give it other useful properties. It does not require a great deal of imagination to appreciate the increased value of clay products that

[1] Presented at the Annual Meeting, American Ceramic Society, Atlantic City, N. J., February 1928. (Refractories Division.) Received December 9 1927.

could be machined, drilled, or turned like perhaps a mild steel, or could be manufactured to close specifications in regard to shape and size; and no one would doubt the value of an increased toughness so that the breaking and cracking of clay ware would be reduced to an insignificant amount. A clay product that would combine all these desirable properties in addition to the customary beauty and durability would be a material without a rival for construction purposes. This appears fantastical, but things just as strange and improbable have been developed and will continue to be developed.

Possible New Method of Clay Processing

This would require not only a great deal of original research, but also investigations in an entirely new direction. Practically all the accumulated knowledge about the properties of clay products is based on investigations with the customary firing processes in mind. This information is important and there is still an unlimited field for investigations in that line, but entirely new by-ways should not be neglected. This would require that our training in ceramic science be of a broader nature, or perhaps would demand the aid of the nonceramic man whose mind is not biased by certain ways of thinking.

The question will at once arise as to what new method of processing clay might be employed to bring about some of the desirable properties suggested. With our present knowledge it is possible to do little more than speculate as to what procedure to use, but one method that comes to mind is some form of chemical treatment. This is a broad subject and not a new one.

The potter who mixes his clay, flint, and feldspar before firing is no doubt reaping the benefit of chemical action. The same can be said of the cement manufacturer who clinkers a mixture of clay and limestone. Yet, in the broad domain of chemistry, countless methods remain untried. The treatment of the clay or shale by some chemical agent in the vapor phase, probably at elevated temperatures and pressures, might be a logical attack. In fact, one of our midwestern universities has a somewhat similar process now in development.

But even if we must adhere to our present method of firing clay in the usual manner, there is room for considerable improvement. When building with fired clay ware we think of structural tile and of brick with its approximate dimensions of long standing, laid up with a mortar of the same nature as used by the Romans many centuries ago. Perhaps the customary shapes and dimensions are not the most ideal, although from the point of view of present methods of manufacture and building, they have some merit; perhaps a better method could replace the customary laying of bricks with mortar.

Any such new development would require that the public be educated to its value. A great aid in this would be to have the new resemble the old in appearance. It might be difficult to introduce a new clay product as a substitute for brick unless it had the appearance of some well-known building material now in common use. When linoleum was introduced as a floor covering, it admitted of a variety of designs not possible in carpets or rugs. The linoleum manufacturers found it expedient, however, to put designs on their linoleums to give them the appearance of natural wood or of tile and later they adapted rug patterns. After a new clay building product has been on the market for some time, it may take on appearances foreign to anything now on the market, which might permit modification in design that would be more practical from the manufacturing or construction point of view. In our laboratories we are now beginning on the first stages of one such new development, but it is too early to predict the outcome.

The manufacturers of fired clay ware are in an industry that is apparently secure, yet they must be alert to adjusting themselves to any new developments. It does not seem likely that for a long time there will be anything to replace their products; yet it might be pointed out that the use of vehicles drawn by beasts for purposes of transportation had been of as long standing as the use of bricks, yet the business of the wagon and carriage manufacturer has dwindled to almost nothing as compared to what it was twenty years ago. The manufacturer who keeps alert to new developments in his business, may never be called upon for any sudden or radical departure from his line, yet he has provided good insurance against possible loss in the future.

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ACID-RESISTANT ENAMELS[1]

By A. Malinovsky

ABSTRACT

The qualities of an acid-resisting enamel are enumerated. Kerstan's formulas are given and results of tests made on the enamels of these formulas are discussed.

Very little available data are published in trade and scientific journals about acid-resisting enamels. Plumbing fixtures with acid enamels have just come into use.

The quality of an acid-resistant enamel is said to depend largely on the ratios of the refractory to the fluxes and to the nature of the fluxes. The ratios must be such that the enamel will not chip, craze, or lift, and must possess good color and gloss.

To be acid-resistant the enamel must contain a high percentage of silica and a low percentage of alkali fluxes. High silica, lead, boric oxide, and zinc oxide are suggested readily because most chemical glasses contain these oxides, some with sodium or calcium or both.

One cannot safely assume that any particular ratio between the refractory and flux or any component is essential for an acid-resisting enamel. Silica is the most essential in acid-resistant enamels and the amount that this enamel may contain depends on the care with which the batch mixture of raw material is made.

In order to insure a good working quality of the enamel it is necessary to have a certain amount of flux but an excess of fluxing oxides will diminish the acid-resisting quality of the enamel. On the other hand an excess of silica makes difficult the smelting and increases the tendency to chip

Published Formulas

Froelich in his two books[2] has published formulas for enamels which he claims are acid-resisting.

Walter Kerstan[3] has also given three formulas for acid-resistant enamels. These formulas are interesting because they contain high cryolite, zinc oxide, tin oxide, sodium antimonate, and high "meltoxyn." The formulas are given below:

TABLE I

	Raw Batch *W* (per cent)	Melted Batch *W* (per cent)		Oxides (per cent)
Silica	5	5.18	SiO_2	31.94
Feldspar	38	39.36	Al_2O_3	7.32
Boric acid	18	10.54	K_2O	3.94
Soda ash	13	7.81	Na_2O	11.65
Sodium nitrate	5	2.93	B_2O_3	10.54
Fluorspar	4	4.14	ZnO	12.43
Cryolite	5	5.18	Cryolite	5.18
Zinc oxide	12	12.43	Fluorspar	4.14
Sodium antimonate	12	12.43	$NaSbO_3$	12.43

[1] Presented at the Annual Meeting, American Ceramic Society, Atlantic City, N. J., February 1928. (Enamel Division.) Received November 25, 1927.

[2] Handbuch des technischen Email, 1920; Practische Email Wissenschaft, 1924.

[3] *Ceram. Ind.*, May and June 1927.

0.0794	K_2O			1.0425	SiO_2
0.5085	Na_2O	0.1681	Al_2O_3		
0.1055	CaO	0.0641	Sb_2O_5	0.0641	B_2O_3
0.3065	ZnO			0.5138	F

The coefficient of expansion of this enamel is 345.06, elasticity 8661.70, tensile strength 6.45, and compression strength 90.09.

TABLE II

	Raw Batch *W* (per cent)	Melted Batch *W* (per cent)		Oxides (per cent)
Feldspar	13.5	20.30	SiO_2	33.39
Silica	13.1	19.63	Al_2O_3	10.04
Borax	17.5	13.91	K_2O	1.92
Sodium nitrate	0.6	.33	Na_2O	18.47
Sodium carbonate	2.8	2.43	B_2O_3	9.64
Cryolite	17.0	25.48	SnO_2	17.99
Tin oxide	12.0	17.99	Fe	13.88

				1.7483	SiO_2
0.0691	K_2O	0.3091	Al_2O_3	0.3742	SnO_2
0.9359	Na_2O			0.4326	B_2O_3
				0.2949	F

The coefficient of expansion of this enamel is 362.74, elasticity 7381.30, tensile strength 6.45, and compression strength 84.99.

TABLE III

	Raw Batch *W* (per cent)	Melted Weight *W* (per cent)		Oxides (per cent)
Silica	28.0	14.47	SiO_2	51.19
Feldspar	24.0	12.41	Al_2O_3	5.26
Ground glass	76.0	39.28	K_2O	1.18
Boric acid	32.0	9.35	Na_2O	14.38
Sodium carbonate	30.0	8.99	B_2O_3	9.35
Fluorspar	3.0	1.55	CaO	3.34
Zinc oxide	3.0	1.55	MgO	0.85
"Meltoxyn"	24.0	12.40	ZnO	1.55
			ZrO_2	12.40
			F	0.76

0.0366	K_2O				
0.6732	Na_2O			2.4723	SiO_2
0.1730	CaO	0.1495	Al_2O_3	0.3878	B_2O_3
0.0618	MgO			0.2949	ZrO_2
0.0554	ZnO			0.1161	Fe

This enamel has a coefficient of expansion 266.49, elasticity 9499.90, tensile strength 7.59, and compression strength 101.60.

The ground glass after Kerstan had the following analyses:

SiO_2	72.0
Al_2O_3	7.5
CaO	5.5
MgO	2.0
Na_2O	13.0

The coefficient of expansion of this glass is 2.53.

The ratios of refractory to fluxes in these three batches of enamel were calculated as follows:

$$\text{Batch I} = \frac{R = 50.32}{F = 49.68} = 1.013\text{R.V.}$$

$$\text{Batch II} = \frac{R = 55.14}{F = 44.86} = 1.23\text{R.V.}$$

$$\text{Batch III} = \frac{R = 68.85}{F = 31.15} = 2.21\text{R.V.}$$

Experimental Work

The object for selecting these three formulas as given by Kerstan was that Batch I contains ZnO and $NaSbO_3$; Batch II has high SnO_2 and cryolite; and Batch III has high ZrO_2. The coefficient of expansion of these three enamels varies from 362.49 to 266.49. The glass was secured from a local glass factory and had the following analyses:

SiO_2	74.60
Al_2O_3	3.96
Fe_2O_3	1.24
CaO	8.00
MgO	.72
Na_2O	11.48

The above three batches have been carefully weighed in 150-pound batches, then mixed and smelted in a U. S. Rotary Smelter. After the frit was dried and ground the enamel was applied on the cast-iron test plates and small sinks. Everything was made in duplicate in order to avoid errors.

After the enameled test plates and sinks had cooled they were subjected to 5, 10, 15, 20, 25%, and concentrated hydrochloric acid. The strengths of these acids were determined by titration with alkali.

All three of these enamels when exposed to the acid for five minutes, were badly attacked especially Batch II. Batch III resisted the acid for 35 minutes before pencil marks would plainly show on the affected spots.

Longer smelting did not increase the resistance to the acid of Batches I and II. They were attacked the same as before. Batch III resisted the acid better but after six hours pencil marks could be made on the affected spots. The color was bad, the enamel had no covering power, and it chipped badly.

These results strengthen the work of Shaw[4] who found that fluorine is decidedly detrimental to enamels which are subjected to acid solutions, when added to enamels as fluorspar or cryolite in large or small amounts.

For the "meltoxyn" in Batch III a well-known zirconium compound was substituted, the writer having in mind that the meltoxyn is perhaps a zirconium compound.

[4] Bur. Stand., *Tech. Paper*, No. 165.

These enamels were also tested for acid resistance by the E. P. Poste methods.[5] Twenty-five per cent hydrochloric acid was used. The frits were dried and placed on a 20-mesh sieve and the returns on a 30-mesh sieve, carefully weighed, and placed into the acid solution for 36 hours. The grains were washed onto filter paper until the washings came through clear and had given no precipitate with silver nitrate solution; these were dried and cooled in a desiccator and weighed again.

By these tests the following results were obtained: Batch I lost 17.41%, Batch II, 29.69%, and Batch III, 6.89%.

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LOS ANGELES, CALIF.

[5] *Trans. Amer. Ceram. Soc.*, **17**, 137 (1915).

STRENGTH OF BRICK IN TENSION[1]

By J. W. McBurney[2]

ABSTRACT

A self-aligning grip for use in testing brick in tension is described. Values for the tensile strength of several types of brick are given. Comparison is made between the transverse and tensile strength of the brick. The conclusion is that the tensile strength is closely related to the transverse strength.

Introduction

During an extended series of tests on the strength of brick masonry in compression conducted at the U. S. Bureau of Standards during 1926 and 1927 in coöperation with the Common Brick Manufacturers' Association of America, the question was raised as to the possibility of the tensile strength of the brick units being an important factor in the compressive strength of the masonry. Brick walls, laid in common bond, quite regularly indicate the approach to the maximum load by the breaking of headers. This may be a transverse, shearing, or tensile failure. It was deemed advisable to determine the tensile strength of the particular types of brick used in the masonry investigation in order to determine whether there was a relation between the tensile strength of the brick and the strength of the walls.

A search of the literature showed very little recorded on the subject of tests of whole brick in tension. Emley and Cleare[3] described an apparatus for tension tests of brick and gave some values. Whittemore and Stang[4] used a modification of the Emley apparatus and reported an average for one make of sand-lime brick. The operation of Emley's original apparatus was extremely time-consuming owing to the necessity of waiting for the gypsum to set as a preliminary to each determination, while the modification used by Whittemore and Stang which consisted of substituting washers of leather for the plaster of Paris, was limited to the testing of comparatively weak brick.

Description of Apparatus and Method of Test

Figure 1 shows a device for gripping the brick which has proved quite successful. With this apparatus, the tensile strengths of brick can be determined at the rate of about ten prepared specimens an hour. The action of this device depends upon the following:

---

[1] Publication approved by the Director of the Bureau of Standards, U. S. Department of Commerce. Presented at the Annual Meeting, American Ceramic Society, Atlantic City, N. J., February 1928. (Heavy Clay Products Division.) Received December 5, 1927.

[2] Research Associate of the Common Brick Manufacturers' Association of America, at the Bureau of Standards.

[3] "How Brick Piers Fail," Proceedings of the Sand-Lime Brick Association, 1920.

[4] "Compressive Strength of Sand-Lime Brick Walls," Bur. Stand., *Tech. Paper*, No. 276.

(1) The brick is gripped by the steel wedges, *W*. Neglecting friction, the compressive force on the end of the brick equals the cotangent of the angle of the wedge times one-half the pulling force. The angle, being 6° 50′, the cotangent is 8.3. The insertion of steel shims between the wedge and the steel face allows for variations in the thickness of the brick.

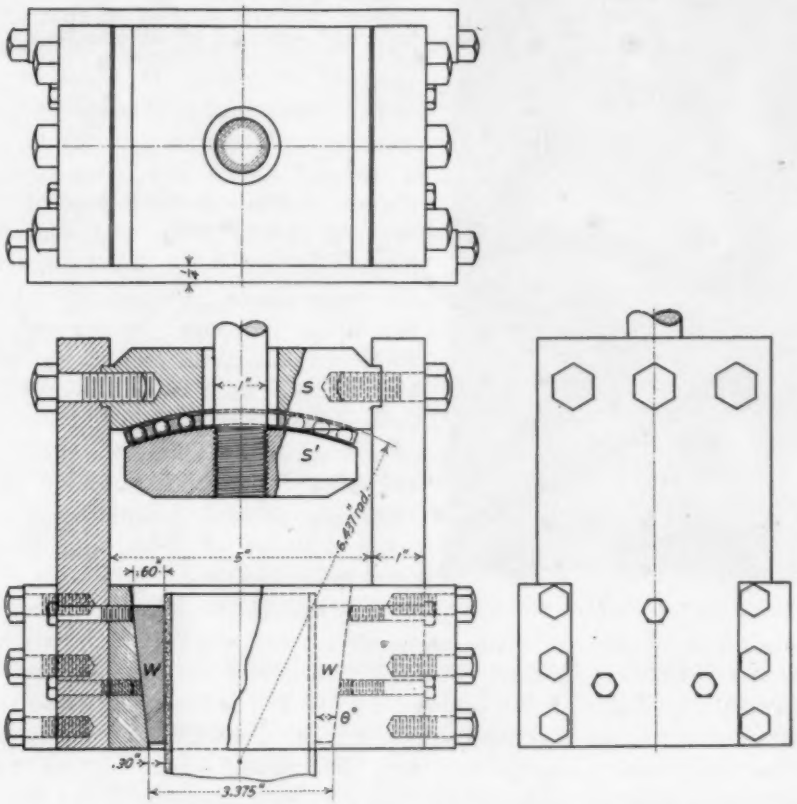

FIG. 1.—Apparatus for determining the tensile strength of brick.

(2) The brick is faced with plaster of Paris. The outer faces of the wedge bear on the steel frame and are well lubricated. The inner faces of the wedges bear on the plaster of Paris facing of the brick. The coefficient of friction of lubricated steel on steel is less than that of steel on plaster of Paris. This is another reason why the brick does not slip in the wedges.

(3) *S* and *S′* are concentric spherical hardened steel surfaces, separated by steel balls $\frac{1}{4}$ inch in diameter. The radius of the outer

surface is large, bringing the center of curvature below the jaws approximately at the center of the brick. This feature of the apparatus assists in securing a uniform tensile stress over the cross-section. Figure 2 shows the apparatus mounted in a testing machine, the test specimen having broken.

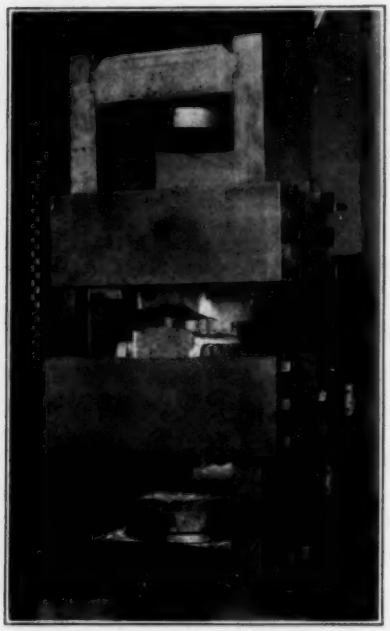

FIG. 2.

The brick to be tested is coated on its two faces with a thin layer of plaster of Paris so applied that the surfaces are parallel. A sufficient quantity of plaster of Paris of a rather thin, pasty consistency, is spread on plate glass and the brick is pressed down into the paste. Plaster of Paris is then applied to the top of the brick and another plate is pressed down, squeezing out the excess plaster. Parallelism of the two plates is insured by the use of three accurately machined spacers between the two plates. They are of such height that the upper layer of plaster is made about $1/16$ inch in thickness. The preparation of the brick can proceed continuously, alternate layers of brick and plate glass being built up.

It is well known that the ultimate strength in tension of brittle materials is very markedly affected by the size of the cross-section. A. A. Griffith[5] found the apparent tensile strength of glass to increase from 24,900 lbs. per sq. in. when the diameter of the test specimen was 0.04 inch, to 491,000 lbs. per sq. in. when the diameter was 0.00013 inch. Riddle and Laird[6] showed that the tensile strength of porcelain increases with decrease of the cross-section of the test specimen.

It must be recognized that we are dealing not with any true or absolute tensile strength but rather with that developed with a given size of cross-section, shape of test specimen, and method of test. Table I gives the values obtained by testing certain types of brick.

---

[5] "The Phenomena of Rupture and Flow in Solids," *Trans. Roy. Phil. Soc.*, **221**, 163–98 (1921).

[6] "A Method for Determining the Tensile Strength of Porcelain," *Proc. A.S.T.M.*, **21**, 1054–56 (1921).

TABLE I

Brick	Strength in tension				Modulus of rupture				Tension/modulus of rupture	
	No. of specimen	Mean	Individual (max.)	Individual (min.)	No. of specimen	Mean	Individual (max.)	Individual (min.)		
		(lb./in.²)	(lb./in.²)			(lb./in.²)	(lb./in.²)			
A	50	417	652	228	100	1318	2420	405	0.32	±0.02
E	50	222	332	137	100	671	1150	151	.33	±0.02
G	110*	246	505	84	110	685*	1826	241	.36	
H	50	601	1160	336	100	1550	2550	853	.39	±0.02
I	50	317	513	141	100	798	1590	332	.40	±0.02
J	49†	210	300	100	50	560†	840	350	.38	

* Tests by A. H. Stang (unpublished data).

† Tests by Whittemore and Stang, Bur. Stand., *Tech. Paper*, No. 276.

In the above table the description of the brick is as follows:

(A) Stiff-mud, end cut, double column, from Chicago district.
(E) Soft-mud brick from Detroit. These brick are manufactured with a frog 0.4 inch in depth.
(G) Soft-mud brick from Cleveland district. Frog as in Brick E.
(H) Soft-mud brick from New England.
(I) Dry-pressed brick from Mississippi.
(J) Sand-lime brick from Ohio.

Bricks A, E, H, and I were tested in the apparatus described in this paper. The transverse strength was determined, using the method described in Tentative Methods of Test for Brick, C67–27T of the American Society for Testing Materials. The degree of variation in the ratio of tensile strength to modulus of rupture, expected because of the error of sampling, has been found by trial to be covered probably by ±0.02.

H. V. Johnson has used this apparatus on half brick from the transverse test and found an excellent degree of correlation for the individual results.

The statement is justified that the relation between tensile strength and transverse strength is more uniform than the relation between transverse and compressive strength or between water absorption and any of the strength properties.

If it is desired to estimate the tensile strength of a brick, a value between 30 and 40% of the modulus of rupture will apparently cover the values as determined.

Summary

(1) An apparatus for making tensile tests on whole brick is described.
(2) The tensile strengths of several types of brick are given.
(3) The tensile strength of the bricks examined are between 30 and 40% of the modulus of rupture.

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Abrasives

PATENT

Multiple-groove-dressing device for abrasive wheels. WILLIAM OWEN. U. S. 1,651,225, November 29, 1927. A dressing device, comprising a frame releasably secured to the work guideway of a grooved abrading wheel, an arm pivoted to frame for movement toward and from the wheel, an adjusting device for the arm, a plurality of dressing rods of abrasive material carried by the arm and adapted to engage the various grooves in the abrading wheel, each of the rods being mounted for rotation about its axis, and gear means for rotating the rods in unison.

Art

Preparation of large single crystals. H. C. RAMSPERGER AND E. H. MELVIN. *Jour. Optical Soc. Amer.*, **15**, 359–63 (1927).—Large single crystals completely filling a thin-walled platinum crucible were made of LiF, NaCl, $NaNO_3$, and $HgBr_2$. A small insulated electric furnace surrounding the crucible with heating coils at top and bottom was heated until the salt melted. The furnace was then cooled slowly, the bottom of the crucible being kept at a slightly lower temperature than the top. A complete crystal of LiF the size of the crucible was obtained. The other salts broke along cleavage cracks during cooling. The apparatus can be used to 1500°C. H.I.

Pottery figures of the Han and T'ang Dynasties. ADELAIDE A. ROBINEAU. *Design*, **29** [6], 111–16 (1927).—A clay problem for the schools which stresses a likeness to life by eliminating detail and preserving action and expression. Many illustrations of early Chinese figurines and Mexican majolicas prove the possibilities, and directions are given for modeling and finishing the pieces, with or without the use of a kiln. E.B.H.

Art of the N. C. potters. FELIX PAYANT. *Design*, **29** [7], 124, 125, 129 (1927).—The native pottery of N. C. has functional fitness, the prime requisite of a genuine piece of art work. Discrimination and good judgment have been shown in the decorative features of this pottery. In most cases the proportions are enough, in others the rhythmic lines resulting from the potter's wheel form a decoration which is a real part of the piece. The variations in the color of the clay or the glaze produced by firing result in fascinating tones and intensities. The line used by the Southern potters is natural and free, the masses, including body, handles, rims, etc., well related. The colors usually are of a soft golden yellow, soft orange, and terra cotta. (Illustrated.) E.B.H.

Early luster ware of Italy. CHARLES HYDE-JOCELIN. *Int. Stud.*, **88** [366], 28–31 (1927).—Many of the processes responsible for early finer ceramic decorations were secret and lost by the death of the discoverer and many, though preserved, are beyond the skill of modern craftsmen to reproduce. Even the 19th Century English revival failed to attain the standard. The luster made at Deruta, Pessaro, and Gubbio evidence the inherent artistry in Italy. The splendid variety, Siculo Arabia, was produced by Moorish craftsmen in Sicily in the 14th Century. Madreperla is ascribed to both Pessaro and Deruta. Gubbio ware ranks highest due to famous Maestro Georgio's efforts during the latter half of the 15th Century. The lustrous surface was obtained by painting over finished work except portions to receive luster. The piece was then fired, the luster applied, and fired again. This firing was done without saggers to allow actual contact with flames and smoke. A small furnace with an upper chamber supported by 2 intersecting arches of brick, the corners left open as vents, was used for the luster firing and was a closely guarded secret. The type of fuel, broom and similar growths in Italy, was an important item. The carbon as smoke coming in contact with heated metallic surfaces, caused them to throw off salts and leave the metalliferous iridescent surface, which was not apparent until the article had been soaked in soapy water, washed, dried, and gently rubbed with wood ashes. Various colors were used, gold and silver being predominant, but on none but Gubbio does the celebrated ruby appear. (Illustrated.) E.B.H.

Orrefors glass of Sweden. JESSICA N. MACDONALD. *Int. Studio*, **88** [367], 33–35 (1927).—Though the glass industry of Sweden is old and well grounded (the first important works starting at Kosta in 1741), and the workmen have rare technical ability, until 10 years ago nothing had been done to rescue the industry from its commercialism. At that time Consul Elkman, permeated by the teachings of Wm. Morris acquired a small factory producing ink bottles, etc., added the best artists (Gate and Hald) and directors, built up a colony around his works, and has overcome the mediocrity of the

19th Century. The Orrefors glass is conceived as a bubble and treated as such in the in the engraved designs, which appear as if modeled upon the surface of the glass. The first experiments were in Grail glass but soon passed on to "Gravestat Kristall" of present renown. They had to combat the diamond cut and substitute the shallow and curved cut. An exhaustive work on the subject by Wettergren has been translated and contains many illustrations. E.B.H.

Lesser known German porcelains. ALFRED M. FRANKFURTER. *Int. Studio*, **88** [367], 49–51 (1927).—Hoechst, Fuerstenberg, and Nymphenburg were three of the porcelain manufactories which grew up in the small German states. The opportunity for their establishment seems to have been the selling of secret processes by a discharged Meissen employee. The golden years of each factory centered around a particular artist: at Hoechst, Melchior; at Fuerstenberg, Feilner; at Nymphenburg, Bustelli. Melchior was the pioneer in introducing the delicate finesse of French art and asserting freedom from the stylistic rococo. Famous Melchior pieces are the Chinese Emperor, Cupid turning the globe, and a striking portrait of his patron, a subject well suited to treatment in porcelain. Feilner's figures are outstanding for their portraiture in contrast to the usual doll-like features. (Illustrated.) E.B.H.

Vases by the Pan-master in America. DANIEL C. RICH. *Int. Studio*, **88** [367], 69–73 (1927).—The Pan-master is outstanding in individuality of stylistic traits among the Attic painters of the 5th Century, representing success in drawing with a return to decorative archaisms such as profile feet, stiff gathered folds of drapery, etc. His vases, in which the figures in the natural red clay stand out against a black varnished background and outlined by brush rather than graver, are identified as "cunning composition." Six of his vases, including the key-vase of Pan are in the Boston Museum, three in the Metropolitan Museum, and one owned by Bowdoin College, a total of ten of the finest extant. The shapes used are the Nolan amphora (Nola, Italy), the lekythos, skyphos, and the krater. The subjects are from daily life or mythology. The bell krater in Boston depicts a sheperd pursued by a goat-headed Pan (hence the name Pan-master) while the obverse is the famous death of Actaeon. This is considered the most finished group in all vase painting. The compositions are all striking and the finish and detail exquisite. (Illustrated.) E.B.H.

Frontispiece. *Int. Studio.*, **88** [367], 1927.—Illustration of 15th Century majolica vase, rare type of early Tuscan, one of 41 presented to Metropolitan Museum by V. E. Macy. It is especially noted for its decorative mingling of oriental and Italian motifs. E.B.H.

Staining of finished glass. W. H. *Diamant*, **49** [8], 144–45 (1927).—(1) The gold or red staining of glass by coating it with a solution containing gelatin and silver nitrate, drying in a dark room, (2) reducing the silver by exposure to light (3) the proper proportions of silver salt necessary for the desired colors, and (4) methods of producing varicolored surfaces by application of different metallic salt emulsions are taken up. E.J.V.

Metallic luster staining and iris effects on glass. W. H. *Diamant*, **49** [8], 145–46 (1927).—The production of metallic lusters by application of solutions of metallic salts, such as chlorides of phosphorus, chlorides, nitrates, or acetates of titanium tungsten, etc., in volatile oils to glass surfaces is discussed. The methods and materials used for the production of colored or colorless lusters are given. E.J.V.

Glass etching inks. ANON. *Pottery Gaz.*, **52** [606], 1913 (1927); reprinted from *Sf. Sdr. Ztg.*—Highly recommended recipes for this purpose are (1) 25 g. barium sulphate and 10 g. ammonium fluoride are mixed in a leaden bowl with enough sulphuric acid to obtain a semiliquid mass; (2) zinc sulphate 1.5, distilled water 50.0, sulphuric acid 6.5; and sodium fluoride 3.6, distilled water 50.0, calcium sulphate 7.0; equal parts of these

solutions are mixed when required for use; (3) (*a*) sodium fluoride 3.6, calcium sulphate 0.7, distilled water 50.0; (*b*) stannous chloride 1.5, hydrochloric acid 6.0, distilled water 50.0; for use equal parts of (*a*) and (*b*) are mixed together; (4) sodium fluoride 2.5, crude hydrochloric acid 1.7, calcium sulphate 2.0, dissolved in 10.0 distilled water. E.J.V.

Roman mosaic pavement. ANON. *Illust. London News*, **171,** 814 (1927).—During recent excavations in a foundry at Dorchester a portion (30×14 ft.) of a magnificent Roman mosaic pavement, evidently part of a villa, was unearthed. It is now in the Dorset County Museum. The same page also illustrates some Roman box-flue tiles, one with a unique hunting design of dog and stag. H.H.S.

Pottery discoveries at Beisan (Beth-shan), Canaan. ALAN ROWE. *Illust. London News*, **171,** 856–59 (1927).—An account of the spade work of the Museum of the Univ. of Pa. during the present season, with 41 illustrations (21 in color). Excavations were carried out in all the levels from pre-Amenophis III (1411 B. C.) to Crusader and contemporary times. The pottery found includes a cylindrical cult-object, models of offering stand and peshesh-Kef implement, an unusual type of pottery filter, faience rings and pendants, dishes, and figurines of goddesses. H.H.S.

Ancient Egyptian mat-blue tile. CECIL FIRTH. *Illust. London News*, **171,** 861 (1927).—Four photographs and letter-press illustrating the excavations at Sakkara for the Egyptian Dept. of Antiquities of times 1700 years earlier than Tutankhamen. The remarkable feature is the mat-blue tile work in the funeral apartment of King Zoser of the 3rd Dynasty. The arched designs include symbols similar to those found in Tutankhamen's tomb, and enough has been found to force the re-writing of the history of Egyptian art and architecture during the earliest and greatest period. H.H.S.

George Salting Collection. ANON. *Weekly Dispatch*, Nov. 13, 1927.—This collection of porcelain and pictures, worth over £3,000,000 is now at South Kensington and the National Gallery. S. was the son of an Australian farmer, and spent a fortune in building up the collection. H.H.S.

BOOKS

Painted Glass of York. F. HARRISON. London: S.P.C.K., 1927. Price 12*s* 6*d*. An account of the medieval glass of the Minster and parish churches, with four colored plates and numerous illustrations. H.H.S.

Battersea Enamels. EGAN MEW. London: The Medici Society, 1927. **English Porcelain Figures of the XVIII Century.** W. KING. London: The Medici Society, 1927. Price each 17*s*. 6*d*. Two volumes of the "Medici Books for Collectors." Each contain about 6 color plates and many monochrome illustrations. H.H.S.

Cement, Lime, and Plaster

Standard specifications for quicklime for use in the manufacture of sulphite pulp. *A.S.T.M. Stand.*, (Series C46–27) pp. 54–55 (1927).—A description of how lime is used in the manufacture of sulphite pulp followed by the requirements of both calcium and magnesium lime, methods of chemical test, sampling, inspection, and rejection. R.A.H.

Standard specifications for hydrated lime for the manufacture of varnish. *A.S.T.M. Stand.*, (Series C47–27) pp. 56–58 (1927). R.A.H.

Standard specifications for quicklime for use in water treatment. *A.S.T.M. Stand.*, (Series C47–27) pp. 64–65 (1927).—A description of the purpose when treating water for public supplies followed by paragraphs on requirements, methods of testing, inspection, rejection, etc. R.A.H.

Standard specifications for hydrated lime for use in water treatment. *A.S.T.M. Stand.*, (Series C54–27) pp. 66–67 (1927). R.A.H.

Standard methods of sampling, inspection, packing, and marking quicklime and lime products. *A.S.T.M. Stand.*, (Series C50–27) pp. 68–71 (1927).—Under methods of sampling the places of sampling, number of samples, size, and how to take either the lump or granular material and the powdered material are described. The treatment of the sample at the laboratory as well as inspection, rejection, retesting, packing, and marking are described. R.A.H.

Standard specifications for gypsum plasters. *A.S.T.M. Stand.*, (Series C28–27) pp. 78–81 (1927).—The definitions for gypsum ready-sanded plaster, gypsum neat plaster, gypsum wood-fibered plaster, and calcined gypsum for finishing coat are given. These are followed by composition, time of setting, and tensile strength. Method of sampling, packing, marking, and inspection and rejection are described. R.A.H.

Standard specifications for gypsum partition tile or block. *A.S.T.M. Stand.*, (Series C52–27) pp. 89–93 (1927).—The definition and use of tile or block is given, together with composition, dimensions, permissible variations, physical properties and tests, sampling, marking, inspection, and rejection. Description of test for determining the compressive and transverse strength and absorption of the gypsum partition tile or block is included. R.A.H.

Standard methods of testing gypsum and its products. *A.S.T.M. Stand.*, (Series C26–27) pp. 94–105 (1927).—Revised from the methods adopted in 1923. In these methods are included the determination of free water in gypsum, fineness, chemical analysis, consistency, water carrying capacity, dry bulk, wet bulk, time of setting, tensile strength, compressive strength, absorption of gypsum partition tile or block, and transverse strength of gypsum boards. R.A.H.

Function of steam in the lime kiln. ERNEST E. BERGER. Bur. Mines, *Tech. Paper*, No. 415.—The primary purpose was to determine whether steam has any effect on the process of limestone calcination. It was found that (1) the first appreciable loss of CO_2 from a high calcium limestone occurs on one hour's heating at 600°C; (2) the limestone is calcined at a slightly faster rate in a current of steam than in air, but the difference in rate is caused by the characteristic physical properties of each gas and is not due to any catalytic or chemical action; (3) use of steam or waste flue gas is effective in preventing clinkering of ash; (4) partial reduction of steam or carbon dioxide to H_2 and CO in the fuel bed increases the combustible gases over it and the secondary oxidation of these gases produces the much-desired long flame in lime burning; (5) only that amount of steam or CO_2 should be used under the grates which will prevent clinkering of ash. Only by an extensive investigation will it be possible to make any definite statement as to the relative efficiencies of steam or CO_2 under the grates. R.A.H.

Investigations on molding (casting) gypsum. M. L. CHASSEVENT. *Sprechsaal*, **60** [36], 650–52 (1927).—Reprinted from the *Bull. de la Soc d'Encouragement p. L'industrie Nationale*, 125 (1926); see also *Ceram. Abs.*, **7** [1], 7 (1928). R.A.H.

Modern Portland cement plant. I. GUTTERIDGE. *The Engineer*, **144** [3750], 610 (1927).—A brief survey of the processes in the manufacture of Portland cement is made. The raw materials are classed as calcareous in which lime predominates and argillaceous with silica and alumina in the greater proportion. The materials pass through 3 stages: (1) preparation of the raw materials, (2) firing, and (3) grinding. Both wet and dry processes are used; in England nearly all of the plants use the wet process. Brief descriptions are given of the kilns, fuel (mostly pulverized coal), quarrying, excavating tools, crushing hard and soft materials, wash mills, storage, measuring machines for wet and dry materials, grinding mills, separators, and driers. G.W.W.

Elutriator for testing cement. ANON. *Rock Prod.*, **30** [23], 53–54 (1927).—Among the various devices for determining the fineness of Portland cement in the size below 200-mesh, elutriators (machines employing rising currents of water to lift the finer

sizes), have not been very successful. One reason is that a fluid other than water must be used and another is that ordinary machines did not guarantee a very uniform velocity to the rising current. The difficulty of using a fluid other than water has been met by circulating the fluid used and filtering it before returning it to the elutriating tube. The uniform velocity of rising current has been attained by using a very neat form of overflow box in connection with a speed regulator on the pump. With these the "head" on the liquid column may be kept constant through hours of work. The velocity given the current is regulated by using a glass jet as the outflow for the liquid. Jets of different sizes (each carefully calibrated) are used to give the different velocities. The liquid which has been found to give good results is sold in England under the name of "White Spirit" and is used by painters as a substitute for American turpentine; when tested the specific gravity at 60°F was found to be 0.792. It begins to distil at 150°C and 98% distils over at 200°C. The apparatus is illustrated and the method of operation is described. F.P.H.

Workability of cement. RICHARD GRÜN. *Tonind. Ztg.*, **51** [68], 1198; **51** [69], 1220–23 (1927).—A discussion of the tests for determining the workability or plasticity of cement and concrete. Apparatus used for this purpose is described. F.P.H.

High-strength cement. HANS KÜHL. *Tonind. Ztg.*, **51** [70], 1245–46 (1927). F.P.H.

Constitution of Portland cement. ERNST JANECKE. *Tonind. Ztg.*, **51** [70], 1246–47 (1927). F.P.H.

Cement industry. ANON. *Tonind. Ztg.*, **51** [70], 1261–64 (1927). F.P.H.

Constitution of Portland cement. H. LUFTSCHITZ. *Tonind. Ztg.*, **71**, 1272–75 (1927); *Rock Prod.*, **30** [24], 102 (1927).—L. draws conclusions similar to those of Kühl based on experimental evidence. Portland cement is a mixture of solid solution of low-lime silicates and aluminates; free lime is present; Janecke's formula for alite, $8CaO.2SiO_2.Al_2O_3$ contradicts the performance of a rotary kiln. To reduce such highly calcareous mixes to a glassy homogeneous substance is outside the range of possible reactions in a rotary kiln. Quantitative molecular differences of low-lime silicates and aluminates cause differences in cements due to their mutual saturation powers. Mono-aluminates and monosilicates of lime are the basic compounds of all cements, with a few possible substitutions. Such properties as hardening and strength are proportional (to a large extent) to their degree of concentration. It is useless to try to establish a formula for Portland cement determinating its exact lime content either in the clinker or after the final set. This is possible only for the main constituents of Portland cement. These constituents of the clinker approach the ideal formula of a glassy blast-furnace slag, which is derived by L. His formula for alite is: $4CaO \cdot 2SiO_2 \cdot Al_2O_3$ which he writes as follows: $Al_2O_3 \cdot CaO + 2(CaO \cdot SiO_2) + CaO$. Cement thus consists of monocalcium aluminate and monocalcium silicate combined in the molecular ratio of 1:2 in an unstable "solid solution," for whose formation or complete saturation lime seems to be a requirement. The monocompounds are present in the clinker in the form of a glass unstable state resembling the constitution of kaolin. The conclusions are based on these points: (1) Portland cement consists of limestone and argillaceous rock; *i.e.*, kaolin, the purest argillaceous substance, combined with purest limestone should yield an "ideal" Portland cement. The practical temperatures of our kilns are insufficient to make use of kaolin in cement production. Its variations, *e.g.*, the ferruginous kinds, are better adapted for this purpose, as their sintering occurs at 1400–1500°C. (2) Nature has provided 2 glassy substances of great strength and simple composition: quartz (SiO_2) and corundum (Al_2O_3). These 2 acid substances combined with bases such as lime must produce the intermediate stages between unstable compounds (slags, cements) and stable solid compounds (porcelain, glass). The mutual presence of silica

and alumina in their anhydrous form seems to form the basis of the hydraulic properties of cements. (3) Nature has also provided a "solid solution" of quartz and corundum in the form of kaolin and its derivatives. (4) Natural Portland cement rock is a mixture of limestone and argillaceous rock, *i.e.*, a non-homogeneous mixture of limestone with a derivative of kaolin. The energy, required for the formation of an ideal glass, must be sufficient to produce the very difficult reaction between molecules of silica and alumina. Energy consumed by cement and slag is greater than that required in the ceramic industries, due to greater fineness of the mass of the latter, although they make use of purer products. As a result, Portland cement is made up of simple monocompounds of lime with silica and alumina, but in a peculiar state, which is designated "kaolinized." The formula for Portland cement starting out with Zulkowsky's (*Chemische Industrie*, p. 280, 1899) formula for kaolin is:

$$\begin{matrix} \text{OH-SiO-O-Al} \\ \\ \text{OH-SiO-O-Al} \end{matrix} \quad \begin{matrix} \text{OH} \\ \\ \text{OH} \end{matrix} > O = Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$$

According to L., Portland cement (alite, Portland cement slag) should be written: $Al_2O_3 \cdot CaO \cdot 2(CaO \cdot SiO_2)$ $CaO = Al_2O_3 \cdot 2SiO_2 \cdot 4CaO$. In the process of hardening, when water is added from the outside, it becomes: (1) $Al_2O_3 \cdot 2(CaO \cdot SiO_2) + CaO + 4H_2O$; (2) $Al_2O_3 \cdot CaO_2(CaO \cdot SiO_2) \cdot CaO + 4H_2O$. A Portland cement would be the result of calcination of a mixture consisting of 25% monocalcium-aluminate (or alumina cement) with 50% monocalcium-silicate and 25% pure lime (calcined lime). The future will see more certainty as to what should be mixed to obtain Portland cement as a result of further studies of mixtures of monocompounds. F.P.H.

German Portland Cement Manufacturers Assn. ANON. *Tonind. Ztg.*, **51** [73], 1319–21 (1927).—Abstracts are given of papers presented at the 50th anniversary celebration of this association. F.P.H.

Weight per unit volume of Portland cement. K. GOSLICH. *Zement*, **38,** 895–97 (1927); *Rock. Prod.*, **30** [24], 98 (1927).—The specifications require in a general way that Portland cement be characterized by high weight per unit volume, without specifying the method of determining this value. Yet the weight per unit volume varies with the method of filling the container, the size and shape of the latter, and other things. The author designed a simple device based on results from years of experimentation which is of considerable accuracy. The following considerations were made in the design, (1) the error is reduced when the quantity of cement to be filled is increased, so a two-liter measure is used; (2) the container is relatively flat to permit the air to escape rapidly; (3) the cement is dumped from a bin above by opening double doors forming the bottom of the bin and permitting the cement to be dumped simultaneously over the entire area; (4) to prevent the cement from clinging to the walls of the bin, the cross-section of the latter is enlarged toward the bottom; (5) the entire apparatus is enclosed in a box, provided with a door on the side, which may be held in closed position by hand. F.P.H.

Crystalline forms in commerical Portland cement. GUTTMANN AND GILLE. *Zement*, **39,** 921–24, **40,** 951–53 (1927); *Rock Prod.*, **30** [24], 98 (1927).—The crystallographic studies were conducted as an attempt to clear the present controversy on the constitution of Portland cement. Dyckerhoff's claim that bicalcium silicate is the main constituent of Portland cement clinker, disagrees with observations by Bates, Phillips, and Rankin who point to tricalcium silicate as the predominant cement mineral. The optical properties of the crystals were studied on 30 thin sections prepared from clinker, of which 18 represented the commercial product and 12 were obtained in laboratories. Their hydraulic moduli varied from 1.7 to 2.3 and their silica moduli from 1.3 to 2.8.

A polarization microscope, equipped for conoscopic observations, was used. The maximum aperture was 1.2. Observations took place by daylight. A number of powdered samples was also investigated. The indices of refraction were determined with an accuracy of 0.003. Five main constituents were thus determined; these were designated as I, II, III, IV, and mixed crystals of high color. The crystalline phase designated as I was found to correspond with alite, as characterized by Tornebohm and others. Similarly II corresponded to belite. The following properties of these 2 main constituents of clinker were established: *Alite:* strong double refraction, crystals with two axes forming a small angle with negative character of double refraction. Refraction exponent $n=1.715$. *Belite:* Strong double refraction with positive character of double refraction, varying angle between axes and varying color. Refraction exponent $\alpha=1.715$ and $\gamma=1.735$. The strongly colored masses, which were found to correspond to celite, consist of several constituents, some of which are isotropic. Their study is to be continued. Other crystals, met with occasionally are: (1) free lime in the form of crystals, (2) β bicalcium silicate (?), in large, optically positive crystals of low double refraction, which correspond to the above compound, (3) colorless glass, at times in considerable quantities, (4) aluminates, isotropic particles, which may be held to be aluminates were found in one instance. With reference to the chemical composition of the main constituents, it may be said that with one exception, free aluminates do not occur in clinkers and as color tests have shown their occurrence in alite the latter may be considered as a formation of mixed crystals of tricalcium silicate with varying amounts of tricalcium aluminate. Belite corresponds to the β and α bicalcium silicate with varying contents of iron and magnesia. No data are yet available on the relation of initial strength to quantities of alite and belite in the clinker. F.P.H.

Study of lead glycerine cements. O. KALLAUNER AND J. POSPISIL. *Trans. Ceram. Soc.* [Eng.], **26** [2], 91–92 (1926–27).—On mixing fine litharge with glycerine a mixture is obtained which hardens quickly with the development of heat and acquires a certain strength. The chemistry of this reaction may be explained by assuming the solution of litharge in glycerine and the formation of lead glycerate which separates out from the supersaturated solution. Hardening begins sooner and its duration is shorter, the more dilute the glycerine and the greater the proportion of lead oxide added. Dilute glycerine (specific gravity, 1.074) gives low strengths with a low proportion of lead oxide, probably owing to the low solubility of the litharge and consequent insufficient formation of lead glycerate. With concentrated glycerine (specific gravity, 1.262) and a low lead content, the decreased strength is probably due to the lack of sufficient lead oxide to form a sufficiently supersaturated solution of lead glycerate. The best mixtures for pouring are obtained with 4 to 5 parts PbO to 1 of glycerine (specific gravity, 1.21–1.26). The modulus of rupture of this mixture is about double the tensile strength. Setting is complete after about 2 days, there being little difference in the strength after 2, 7, and 28 days. Water, strong inorganic acids, and sodium bases have an unfavorable effect on the bond. Sulphuric acid dissolves the lead glycerate, lead sulphate being formed, while sodium bases form sodium plumbate. Nitric acid transforms the lead into soluble lead nitrate. The actual adhesion of the cement to metals is comparatively slight, but metal parts embedded in the cement become firmly fixed owing to the contraction of the cement during setting. The addition of small quantities of nitric acid to the glycerine prolongs the setting period; sodium hydroxide and ammonia shorten the period. R.F.S.

Microchemical study of gypsum. P. P. BUDNIKOFF. *Zeit. anorg. u. allgem. Chem.*, **155**, 141 (1926).—Experiments are described having the object of "revivifying" dead-burned gypsum by means of catalyzers such as acid salts of alkali metals. Photomicrographs show the crystalline structure of revivified gypsum after absorption of water. (*T.E.C.S.*)

PATENTS

Treatment of sand-lime mixture. French 599,918; *Rock Prod.*, **30** [23], 79 1927. To make sure that all lime in the mix becomes hydrated, the mass is introduced with water into a revolving autoclave and steam under pressure admitted. F.P.H.

Enameling articles made of fibrous cement. French 610,956; *Rock Prod.* **30** [23], 78 (1927). The well-dried article from which all grease has been removed is covered with a thick paste made by mixing stannic oxide, cryolite, and a pigment with powered flux and water, and, after drying, the article is heated until the flux melts. The flux is made by melting together silica, red lead borax, and niter, with subsequent grinding to an impalpable powder. F.P.H.

Manufacture of cement, lime, or gypsum products. Ger. 421,423; *Rock Prod.*, **30** [23], 79 (1927). According to Ger. 418,708, ceramic products are densely compacted by subjecting them upon molding to a uniform pressure from all sides while immersed in a gaseous, liquid or other medium in a tightly closed space. The same process can be applied to gypsum, lime, cement products, etc. The products acquire high strength in a short time of pressure application. F.P.H.

Hydration of hydraulic lime. H. SPORRL. Swiss 106,952; *Rock Prod.*, **30** [23], 78 (1927). Slaking proceeds at higher temperatures than the temperature naturally developed during slaking. This is accomplished by admitting hot gases to the lime in one or several hydraters. F.P.H.

Enamels

Enamel science and enameling technique in 1926. E. URBSCHAT. *Keram. Rund.*, **35,** 7–10, 44–45 (1927).—A review of the literature for 1926 on enamels and enameling. H.I.

Delicate shades for sheet-iron vitreous enamels. K. B. STRONG. *Ceram. Ind.* **9** [6], 692 (1927).—Formulas for the following colors for vitreous enamel for sheet iron are given: flesh pink, pink, billboard rose pink, deep purple, medium purple, lavender, violet, sky blue, cream or ivory, and brown. F.P.H.

Light-colored first-coat enamels for sheet iron. ANON. Bur. Stand., *Tech. News Bull.*, No. 127, p. 10 (1927).—Data are given showing the effect of firing treatment upon adhesiveness of light-colored first-coat enamels upon irons having received a series of different treatments. R.A.H.

Apso: new corrosion-resisting material. ANON. *Chem. and Ind.*, **46,** 1130 (1927).—Made in France by the Aciéries de Pompey, this new metallic product possesses resistance, workability, strength, etc., similar to, and in some instances better than, nickel steel, at smaller cost. H.H.S.

Blistering of white enamel on faulty cast iron. K. MEURES. *Emaillew. Ind.*, **2,** 69 (1927).—The effect of excessive sulphur (0.153%) in cast iron is described. (*T.E.C.S.*)

Acid-resistant colors; testing. EISENLOHR. *Sprechsaal*, **59,** 645; *Chem. Zentr.* **2,** 2472 (1926).—All fluxes containing 1.3 to 2% SiO_2 to 0.7 PbO, 0.3 NaO are resistant to acids. For purposes of testing, the colors, after application to the ware, are exposed to 3% HCl for at least 5 hours. They should then not lose any of their gloss. (*T.E.C.S.*)

PATENTS

Titanium pigments. E. C. R. MARKS. Brit. 266,211, Aug. 6, 1926. Titanium ores are treated with an alkali sulphate and an acid at a temperature below fusing point until a solid cake is obtained, which is then cooled, crushed, and extracted with water. The ores are subjected to a preliminary treatment to remove iron. (*T.E.C.S.*)

Glass enamels. PATENT-TREUHAND GES FÜR ELEKTRISCHE GLUHLAMPEN. Brit. 267,815, Sept. 25, 1926. Readily-fusible glasses or enamels, particularly intended for

coating electric lamp bulbs, consist of a basis of lead-zinc borate having the following composition: 60–75% lead oxide; 10–25% zinc oxide; and 15–30% boric oxide. The enamel may be made opaque by any known agents, but it is preferable to add a quantity, up to 2% of each, of arsenic and ammonium nitrate. (*J.S.G.T.*)

Glass

The window-glass industry. H. E. ALLEN. *Nat. Glass Budget*, **43** [32], 6 (1927).—The causes for the instability of the window-glass industry are discussed and the effect of foreign importations noted. It is urged that a petition be presented to the Tariff Commission to redress grievances confronting the industry.

Radiation method of measuring strain in glass. C. E. MENDENHALL, L. R. INGERSOLL, AND N. H. JOHNSON. *Jour. Optical Soc. Amer.*, **15,** 285–89 (1927).—A method of measuring strain, especially applicable to rough-surfaced and opal glasses is described. Light from a point source after passing through a specimen placed between crossed nicols is focussed on a small thermopile connected to a sensitive galvanometer. The maximum galvanometer deflection observed on rotating the crossed nicols is a measure of the strain. Certain corrections must be made. The method is not applicable for strains causing a phase difference of much more than a quarter of a wave-length. Results on specimens of opal and diffusing glasses are given. H.I.

Solution and absorption of gases by glass. E. RICHARDS. *Keram. Rund.*, **35,** 20 (1927).—Three glasses, a barium flint, a thermometer flint, and a borosilicate, the analyses of which are given, were heated in an electric furnace under reduced pressure. Foaming of the glasses resulted. The gases produced were analyzed and the results of the analyses are given in terms of O_2, CO_2, and N_2. R. suggests that gas bubbles may be caused by tension in the interior of large masses of glass during cooling and by the sucking up of glass in the Owens machine. H.I.

Work of Johann Kunckel. W. MYLIUS. *Keram. Rund.*, **35,** 38–41 (1927).—A review of K.'s work (1630–1703) in the production of ruby glass vessels. Photographs of his products are given. H.I.

Effect of temperature of the stress-optical behavior of glass. K. OKUDA. *Kyushu Univ. Coll. Eng. Mem.*, **4,** 159–91 (1927); *Sci. Abs.*, **30,** 746 (1927).—O. concludes from the experimental results that artificial double refraction of glass is due to molecular orientation and molecular strain. D.E.S.

Absorption of optical glass and borax below 4.1μ. T. DREISCH. *Zeits. f. Physik*, **42,** 428–34 (1927); *Sci. Abs.*, **30,** 623 (1927).—Optical glasses generally absorb little up to 2.7μ; beyond this absorption rises rapidly. In glasses containing B_2O_3 sharp bands occur at 2.8, 3.68, and 4.05μ and the intensities of the bands increase with increasing B_2O_3 content. They correspond to bands in borax at 2.95, 3.65, and 4.1μ. SiO_2 causes diffused bands at 2.85 and 3.55μ. D.E.S.

Shooting through glass with a rifle. F. W. PRESTON. *Jour. Soc. Glass Tech.*, **11** [43], 283–86 (1927).—The oft repeated statement that a bullet can be fired through glass without cracking it, owing to the inertia of the latter, is shown by P. to be a fallacy. High powered bullets fired through window and plate glass gave conical shaped holes about $2^1/_2$ times the diameter of the bullet on the front face and about eight times its diameter on the opposite face. A very large number of fissures radiate from the hole in a rosette pattern and are crossed by a number of circumferential fissures. In thick or undamped sheets, the glass is fractured at a distance from the hole due to the vibrations set up by the impact of the bullet. Before the bullet fractures the front face of the glass, it so deflects the glass as to cause its collapse on the rear face. D.J.McS.

Glass houses of Dudley and Worcester. F. BUCKLEY. *Jour. Soc. Glass Tech.*, **11** [43], 287–93 (1927).—A history of the glass houses of Dudley and Worcester during

the 18th and early part of the 19th Centuries. Production consisted mainly of flint glass ware. D.J.McS.

Gaseous fuels for furnace heating. R. WIGGINTON. *Jour. Soc. Glass Tech.*, **11** [43], 293–300 (1927).—Gas rich in carbon monoxide is to be preferred on account of its longer flame, greater radiating power and lesser liability to surface combustion. Use of a 45° steam saturation in producers gives the best results. Proper control of steam blast essential for best practice. D.J.McS.

Properties of some soda-lead oxide-silica glasses. S. ENGLISH, W. E. S. TURNER, AND F. WINKS. *Jour. Soc. Glass Tech.*, **11** [43], 300–303 (1927).—Determinations of annealing temperature and coefficient of expansion made on a number of glasses corresponding to the general formula $6SiO_2(2-x)Na_2O.xPbO$. The annealing temperature falls as lead oxide is substituted for soda and varied from 478°C to 446°C in this series. The value of $\alpha \times 10^{15}$ varied from 1090 to 842, inversely as the lead content. Calculation of the cubical expansion constant for lead oxide gave the value 3.18×10^7. D.J.McS.

Glass melting furnaces. W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **11** [43], 303–31, (1927).—A review of the changes and improvements in glass furnace operation in England since 1914. Great improvement resulted from the change from direct fired to regenerative or recuperative furnaces. Wearing of the eye of pot furnaces may cause a considerable increase in fuel consumption. Average results obtained with British pot furnaces better than those of similar furnaces in Germany. Pot furnaces more compact than formerly; can be operated at higher temperatures with much smaller fuel consumption and longer life. British tank furnaces melted a ton of glass in as low as 6.6 sq. ft. melting area on as little as 11 cwt. of coal per ton of glass. Improvement in tank furnace efficiency is due to the use of a dog house, better port design, better proportioning of gas and air, use of a shadow wall, and abandonment of the port in the working end. D.J.McS.

Electrical conductivity of glasses at high temperatures. F. F. S. BRYSON. *Jour. Soc. Glass Tech.*, **11** [43], 331–47 (1927).—Review of work previously done on the conductivity of glasses above 200°C. Greatest difficulty in conductivity measurements are due to polarization. Measurements are made between 600° and 1100°C with high frequency alternating currents and resistance measured by a bridge method. The conductivity of glasses is increased by substituting soda or magnesia for silica and is decreased by substituting alumina for soda. As the conductivity of a glass varies with the temperature in the same order as the viscosity, B. suggests plant control of glass viscosity by the determination of its electrical conductivity. D.J.McS.

Brittleness of opal glass. G. GEHLHOFF AND M. THOMAS. *Jour. Soc. Glass Tech.*, **11** [43], 347–62 (1927).—The brittleness of opal glass as determined on bulbs by an impact test and on balls by a thermal endurance test is greatly affected by the temperature at which the glass is worked. On a particular dense opal having an upper devitrification temperature of about 1050°C, bulbs made at a working temperature above this, were very much less brittle than those made at a lower working temperature. The brittleness varies with increase in the working temperature below or above the upper devitrification temperature. The crystals present in the glass were coarser and less uniform when the glass was worked at a low than when it was worked at a high temperature. A thermal analysis of the glass showed a transformation, apparently due to heat absorption, at the upper devitrification temperature. D.J.McS.

German glass industry. ANON. *Ceram. Age*, **10** [4], 139 (1927).—The glass industry in Germany attained peak post-war production in 1925 but manufactured only about 70% of this in 1926, approximating the 1924 output. The 1926 production was about 50% of capacity, the decline being attributed to less building activity. The movement toward concentration into syndicates and mechanical improvement char-

acterized the German glass industry during 1926. Bottle making and electric light bulb plants are quite up to date; plate-glass producing installations are progressing but small plate-glass producers still cling to antiquated methods. A.E.R.W.

Glass tank operation improved by the use of preheated air. W. DRYSSEN. *Fuels and Fur.*, **5** [12], 1631–32 (1927).—A continuous regenerative type air heater was recently installed on a large glass tank, which was fired with natural gas and required as high an air preheat as possible. The reversal and flow of waste gas and air take place automatically within the heater itself, the flow of gas and air to the heater being continuous. The construction of the heater and its operation are described. The heating elements consist of steel sheets $^1/_{16}$ in. thick. Chromium steel is used where the temperatures are high. Frequent reversals of flow keep the heating elements free from dust. The average results obtained are shown in tables. Although temperatures exceeding 1500°F have been obtained, 16 months' service caused no deterioration. The heater will handle safely a waste gas temperature of 2000°F. A.E.R.W.

The glass industry at the year's end. LUDWIG SPRINGER. *Keram. Rund.*, **35**, 5–7 (1927).—A review of technical advances in 1926 under the headings, raw materials, firing technique, composition, and production of special glasses. H.I.

Construction of the pot-tempering furnace. EGON ARNOT. *Sprechsaal*, **60** [35], 633–34 (1927).—Some improvements are shown for better and more uniform temperature control in pot arch furnaces. R.A.H.

Cerium as a raw material and constituent in glass. H. HEINRICHS AND GEORG JAECKEL. *Sprechsaal*, **60** [39], 705–707; [40], 730–31 (1927).—Discussion on source and use of cerium in glass making with a method of analysis for its determination in ores and glass. R.A.H.

Modern glass mixtures. OSKAR LECHER. *Glass Ind.*, **8** [12], 279–81 (1927)—Yellow and brown glasses are among the most difficult colors attainable in the production of glass, since it is difficult to hit any definite color tint desired, the color of the melt obtained usually being of a lighter or darker shade. The large number of different methods and recipes indicates the degree of difficulty in obtaining exact shades. The following substances will give reliable results, (1) light yellow-Rhine wine bottle brown, manganese oxide and iron oxide; brownish orange-mahogany brown, sulphur in glasses free of lead; fiery canary yellow, cadmium with or without sulphur, particularly in lead glasses; greenish-yellow, uranium oxide, eventually with chromium oxide; reddish-orange, uranium oxide with selenium; red-brown, carbon powder, especially charcoal powder. All other tints are produced by modifications of the above coloring agents. A discussion of colors obtained with other agents and a number of reliable mixtures for the production of various color tints for different furnaces available, and the qualities of glass described are given. The production of selenium ruby is discussed and several mixtures giving satisfactory results are given. The process of yellow silver glazing is described. E.J.V.

Automobile glasses. E. WARD TILLOTSON. *Glass Ind.*, **8** [12], 282–83 (1927).—For abstract see *Ceram. Abs.*, **7** [1], 20 (1928). E.J.V.

Cost of making glass ware. ANON. *Ceram. Ind.*, **9** [6], 676–77 (1927).—The article shows the cost of producing glass in both man and machine hours. It is an abstract of the U. S. Bureau of Labor Statistics, *Bull.*, No. 441 and was prepared by Boris Stern of that Bureau. F.P.H.

Changes taking place on optical glasses. P. NICOLARDOT. *Rev. gén. colloïdes*, **5**, 445–49, 491–96, 539–43, 592–98 (1927).—A review. (*C. A.*)

Arsine from fused glass. H. M. ELSEY. *Science*, **66**, 300 (1927).—When borosilicate glasses are heated and stretched an odor of arsine is detected. The odor might be due to gaseous As. The odor was noticeable only when fresh free surface was being

formed in glasses which contained 0.5% and 0.8% As. The source of the odor is most likely the reaction represented by $4As+3H_2O \rightarrow As_2O_3+2AsH_3$. This reaction is similar to the reaction between P and H_2O at high temperatures. $4P_2+12H_2O \rightarrow 3H_3PO_4+5PH_3$. (*C. A.*)

The stability of alkali-lime glass. OSCAR KNAPP. *Sprechsaal*, **59**, 199–201 (1926); *Chem. Zentr.* II, 95, 1926.—The stability is a constitutive and additive property. (*C.A.*)

Lead crystal. L. SPRINGER. *Sprechsaal*, **60**, 481 (1927).—The older conception of a "flint" glass was that of one containing at least 30, generally 33, and rarely more than 38% of lead oxide, although for optical purposes as much as 80% was used. Improvements in firing enable light flints containing up to 22½% of lead oxide to be made in open pots. More recently still a cheaper demicrystal with less than 10% of lead oxide, with calcium or barium oxides, or both, has appeared on the market. The following limitation of terms is suggested: heavy lead crystal, lead oxide above 30%, light crystal, from 17 to 23%, and demicrystal from 7 to 13%. The question of differentiation arises for those not expert, and in this connection color and luster are perhaps the best guides, together with density, and the fact that the cutting and polishing are not so good in the lighter wares. (*J.S.G.T.*)

BOOK

Glass-melting Tank Furnaces. H. MAURACH. Wärmetechnische Beratungsstelle der deutschen Glasindustrie, Frankfurt am Main, Germany. Chapters on the following subjects are given; (1) comparison of pot furnace, day tanks, and continuous tanks, (2) the most usual styles and designs of continuous tanks with regenerative firing, (3) the most usual styles and designs of day tanks with regenerative firing, (4) heat-transfer and temperature distribution in the heating chamber, (5) relations between size, service, and heat consumption of tank furnaces with regenerative firing, (6) regenerators, (7) burners for tanks with regenerative firing, (8) tank furnaces with recuperative firing, (9) various other subjects such as annealing, insulation, etc. Considerable data have been collected on about 57 glass tank furnaces concerning the design and dimensions of the furnaces, type of fuel, type of glass ware manufactured, fuel consumption, life of various parts of furnace, etc. These data are summarized in 7 tables. This book is a valuable contribution to knowledge of glass-tank design and construction and contains information that should be valuable to the glass technologists. F.P.H.

PATENTS

Heating means for sheet-glass apparatus. JOHN C. HENDERSON. U. S. 1,649,031, November 15, 1927. In sheet-glass apparatus, means for drawing a sheet from a mass of molten glass, and means for passing an electrical current through the sheet to heat it.

Glass-forming machine. GEORGE E. ZEILER. U. S. 1,649,641, November 15, 1927. A glass-forming machine comprising a vertically movable forming member and a vertically movable member coöperating with it to support a plastic article, and means for causing one of the members to move at a greater rate of speed than the other.

Glass-forming machine. RICHARD LA FRANCE. U. S. 1,650,368, November 22, 1927. In a glass-forming machine, the combination of a neck mold, means coöperating therewith to form a parison of glass extending upward from the neck mold, a sectional finishing mold beneath the neck mold, means to invert the neck mold and thereby swing the parison downward to a depending position between the open finishing mold sections, a centering arm between the mold sections in position to arrest the parison when the latter has swung a short distance beyond a central position with respect to the finishing mold, and means to then advance the arm to center the parison and then withdraw the arm to clear the finishing mold and permit it to inclose the parison.

Apparatus for handling glass ware. WILBUR S. MAYERS. U. S. 1,650, 900, November 29, 1927. In glass ware handling apparatus, in combination with a ware carrier,

a pusher for the ware suspended for vertical and horizontal movements, and actuating means for the pusher adjustable to vary the amplitude relation of the movements.

Apparatus for feeding glass. WILLIAM J. MILLER. U.S. 1,651,036, November 29, 1927. In means for feeding glass to a mold or other receiver arranged to travel about an axis, in combination with a tank for molten glass, a shallow extension of the tank receiving glass therefrom and provided with a discharge orifice, a movable receptacle in which a supply of glass is maintained from the shallow extension, the receptacle being provided with a discharge orifice through which a portion of the glass travels to form mold charges, reciprocal means working in relation to the discharge orifice of the receptacle to control the passage of glass through it, means for severing the glass protruding through the discharge orifice of the receptacle to detach the mold charges, and means for moving the receptacle about the same axis to cause the orifice to travel with the mold and vertically aligned therewith during the feeding operation.

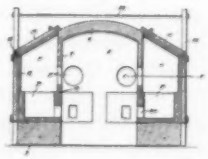
Plate glass surfacing apparatus. WILLIAM OWEN. U. S. 1,651, 224, November 29, 1927. In combination in a surfacing machine, a frame, a vertically movable fluid operated plunger mounted therein, a horizontal laterally swinging arm carried by the plunger, a surfacing unit comprising a motor, runner shaft, and runner carried by the arm, means independent of the operating fluid for adjusting the plunger vertically, a track extending transversely beneath the runner, and a glass supporting table mounted for movement along the track, the arm being mounted to swing in an arc such that the runner may be positioned either over the track or to one side.

Vitreous enamel composition and method of making same. GEORGE MCINTOSH SCOTT. U. S. 1,651,474, December 6, 1927. Process for production of vitreous enamel compositions which comprises mixing together one or more oils, enamel frit, a coloring oxide, and a mineral grease or jelly such as petroleum jelly, to substantially a pasty consistency.

Glass composition. WILLIAM CHITTENDEN TAYLOR. U. S. 1,652,259, December 13, 1927. The process of making a clouded glass comprising adding to a batch free from substantial quantities of lead and containing at least 3% boric oxide, a relatively high percentage of silica and only a relatively small percentage of alumina, an opacifying agent in the form of a sulphate salt, and melting the mixture under conditions which do not result in a volatilization of the sulphur content.

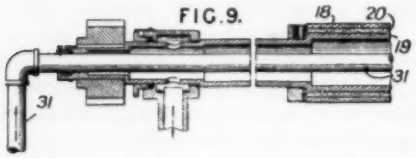
Sheet glass abrading means. ARCHIE W. PLATT. U. S. 1,652,410, December 13, 1927. In an apparatus of the class described, a pair of polishing rolls disposed in transversely spaced parallel relation, a receptacle mounted for rocking movements above the roll axes and substantially midway between and having a narrow bottom portion with a discharge opening therein extending a distance between the rolls, a distributing roll carried by the receptacle and substantially closing the bottom opening and adapted to be moved into engagement with the periphery of either polishing roll by a rocking of the receptacle.

Glass tank furnace. CHARLES L. CLARK. U. S. 1,652,608, December 13, 1927. In combination, a glass furnace nose or working end having ring holes, a base built about the lower portion of the nose, a housing superimposed upon the base about the sides and end of the nose, pots in the housing communicating with the interior of the nose through the ring holes, openings being provided in the sides of the pots for this purpose, the housing being divided into a plurality of compartments, each compartment being formed with a side and upper opening, a door structure for closing the opening, each door comprising a lower section hinged to the housing and an upper section hinged to the lower section.

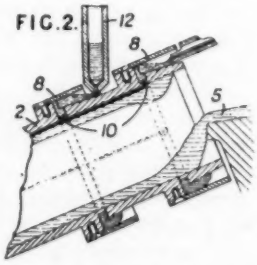


Compound glass sheets. P. H. Head and Safety Glass and Xetal Products, Ltd. Brit. 277,044, November 2, 1927. To prevent discoloration of the celluloid or like sheet in the manufacture of strengthened compound glass sheets a bleaching agent such as tetrachlorethane or other chlorine derivative is incorporated in the celluloid solvent or separately applied to the celluloid. The solvent preferably consists of industrial spirit, amyl acetate and tetrachlorethane and two sheets of glass previously coated with gelatine and a sheet of celluloid are immersed in the solvent and united by pressure. In uniting large sheets, vulcanized rubber is preferably applied to the platens of the press. The proportions of the ingredients used in the solvent are preferably 2 parts tetrachlorethane, 3 parts amyl acetate, and 3 parts industrial spirit. The gelatine is applied to the glass sheets from a solution of 1 g. to gelatine to 1 fluid ounce of water.

Glass manufacture. H. Wade. Brit. 277,070, November 2, 1927. The parts of apparatus for shaping or feeding glass which are in contact with the hot plastic glass are made of, or faced with, fused silica. As applied to the Colburn or other processes for drawing sheet glass, the bending rolls, and other rolls in contact with the metal or plastic sheet, consist of steel rollers with an outer covering of fused silica. The steel core of the roller is hollow and water is circulated through it to keep the silica covering below its devitrifying temperature. The bending-roll used with the Colburn process may be replaced by a series of silica covered rolls over which the sheet passes in turning from the vertical to the horizontal position. The slotted forming-block, or "debiteuse," used with the Fourcault system may have the slot, sides, and bottom faced with a layer of fused silica. A preferred form of roller consists of a hollow metal body (19) of nickel steel, the material known under the registered trade mark "Invar," or nichrome covered with a layer (20) of high temperature cement, such as the material known under the registered trade mark "Thermolith," which serves as a cushion for the outer layer (18) of fused silica. Water is circulated through the roll from a pipe (31). The body (19) is serrated or roughened to give better adhesion for the cement (20). Such rollers may also be used with sheet-forming apparatus in which the metal is flowed downward or laterally through a slot into a pass between rollers. The outlet nozzles and shaping-devices of feeders may also be coated with silica. Tank-furnace blocks, particularly those around the general level of the glass in the tank, may be faced with fused silica.



Glass manufacture. S. G. S. Dicker. Brit. 277,807, November 16, 1927. A method of continuously drawing tubes or rods composed of two or more layers of different kinds of glass, or of glass with a colored stripe. Two or more streams of molten glass are caused to flow on to a rotating member to form layers which fuse together, and the combined layer is drawn off the end of the rotating member as a tube or rod. In the construction shown in Fig. 2, a stream of glass (5), flows from a tank furnace into the interior of a cylinder (2) which is rotated by suitable means and is heated electrically. Other streams of glass flow from containers or shoots (12) into annular reservoirs (8) formed on the outside of the cylinder (2) whence they pass into the interior of the cylinder through apertures or slots (10). The cylinder is inclined downward, and the combined layer formed by the different streams of glass is drawn away from the lower end as tube or rod. The cylinder may be replaced by a mandrel and the streams of glass fed onto its outer surface.



Heavy Clay Products

Progress report on the efflorescence and scumming of mortar materials. HEWITT WILSON. *Jour. Amer. Ceram. Soc.*, **11** [1], 1–31 (1928).—A general discussion of soluble salts in clays, clay products, and mortar materials and the addition of barium compounds to make the salts insoluble. Twenty-one, 4-x4-foot panels, 8 inches thick were constructed of the same glacial-clay, red, face brick with variations in the following common mortar materials: sand, slaked lime, hydrated lime, and Portland cement. Saturated brick was tried versus dry brick; sea water was used to replace fresh water; machine-mixing of the mortar batch was tried against hand-mixing; and various percentages of barium carbonate, barium hydroxide, and barium chloride were introduced to make the calcium sulphate insoluble. Temporary scum or that obtained in the original drying of the wall was noted and later or permanent scums, produced by artificial and natural soaking and drying of the walls were studied for over a year. All the mortars studied can be made to scum if sufficient water and time of contact of water and mortar are provided. The troublesome salts are: (1) calcium sulphate largely introduced by the Portland cement, which makes a very bad, early scum; (2) calcium hydroxide from the free lime and hydrolyzed calcium aluminates and silicates in Portland cement and from uncarbonated lumps of lime in the lime mortars; in addition, some minor salts from special sources, such as sodium chloride from sea water. Lime mortar streaks were only produced after a large quantity of water had been washed through the panel, and were apparently formed by finely divided or colloidal lime hydroxide or carbonate in suspension in the water running from the porous mortar down the side of the wall. This is a very severe soaking condition and is not common in the ordinary building wall. The lime sulphate dissolves readily enough to pass in solution through the pores of the brick and to spread uniformly over the brick surface. Lumps of hardened lime should be removed from both slaked and hydrated lime to prevent streaks of lime hydroxide and carbonate on the surface under wet conditions for long periods of time. Lumps of lime also produce spalling. The interior of a wall should be well protected from leaky drains, gutters, etc., which permit water to get inside. A hard rain of short duration is not as bad as a long, soaking drizzle which permits the water to remain in contact with the mortar for a longer period of time. Cement products, such as artificial cement stone, commonly release salts which drain onto other facing materials. The tests indicated that barium carbonate is effective under normal conditions in preventing or minimizing calcium sulphate scum from Portland cement. This has been checked on large Seattle school buildings where the conditions are favorable for scum. Five per cent barium carbonate in terms of Portland cement has been used successfully. It has been suggested (but not tried) that diatomaceous earth may combine with the free lime of the mortar materials to produce a more insoluble calcium silicate and reduce the temporary scum of lime hydroxide. The study is being continued on the chemical analysis and composition of the scums taken from the surface of the walls and leached in the laboratory from separate batches of the mortar materials. Preliminary analyses have already been made. The strength of the mortar materials to note the effect of barium salts is also under study. No deleterious effects have been found from barium salts.

Determination of soluble salts in clays and ceramic ware. O. KALLAUNER. *Trans. Ceram. Soc.* [Eng.], **26** [2], 88–90 (1926–27).—During the year 1926 a series of investigations was carried out in the Silicate Research Department of the State Institute of Technology, Brno, and the results of this investigation are as follows: Methods were studied in detail for determining the soluble salts in clays and ceramic ware, from both the theoretical and practical analytical points of view. The methods examined included those of Seger and Cramer, Kreibing, Ludwig, Bollenbach, the German Institute for Testing Materials, in Gross Lichterfeld, and the International Standard Test for

Constructional Materials. Several of these methods are open to objection on the grounds of inaccuracy, slowness, or unsuitability. The following observations are based on the results of experiment of the investigators: (*a*) the quantitative method based on simple sedimentation of clays and crushed products in aqueous suspensions requires a very long time, since the supernatant liquid remains turbid even after several weeks; (*b*) quantitative methods based on filtration through filters of fired ceramic material, *e.g.*, the Pukall and Berkefeld filters, give better results and are much quicker; (*c*) methods of determining the soluble matter by measuring the electrical conductivity of clay suspensions may afford interesting information but their accuracy cannot be guaranteed; (*d*) the method of determining qualitatively the amount of soluble matter in ceramic products, as advocated by the Chemical Laboratory for the Ceramic Industry, Seger and Cramer, in Berlin, takes a very long time to carry out and in many cases is unsuitable. The method adopted which is quicker and more exact is as follows: A half or full brick is placed in a porcelain dish containing distilled water into which the end of a tube leading from a vessel containing more distilled water extends. As the level of the water in the dish falls owing to seepage into the brick, the supply is replenished from the vessel until the original level is reached. The vessel is graduated so that the quantity of water passed into the dish can be measured. At room temperature, absorption takes place slowly; in order to hasten the process, heating the upper surface of the brick with an electric light provided with a high-temperature reflector and placing the dish on a hot-water bath is recommended. By this method a correct qualitative determination can be made in a few hours. R.F.S.

Injurious effect of nodules in brick products. O. KALLAUNER. *Trans. Ceram. Soc.* [Eng.], **26** [2], 90 (1926–27).—To find out to what extent nodules in fired products may be harmful, the test which most nearly approaches the conditions of practice is to expose the products for a more or less lengthy period to the open air. The injurious effect of nodules will then be indicated by the development of fissures, cracks, etc., or even by complete disintegration, or the "ring" may change from a clear to a dull sound. The best and quickest results were obtained by the wet-steam test. To determine the harmful effects of nodules in roofing tile, five tile are put on the false bottom of a vessel, which is covered by a lid. Water below the lid is heated for one hour until it boils and is held at this point for another hour. Four hours after this treatment the tile are inspected for cracks, etc. This method has been introduced as an official specification test in Czechoslovakia. R.F.S.

Cost methods for manufacturers of clay products. I and II. WILLIAM H. COMPTON. *Ceram. Age*, **10** [4], 119–21 (1927).—Cost systems are no more complicated than any manufacturing process. Besides determining prices and securing efficiency, they discover opportunities for economy and expansion. Cost systems are frequently more complicated and expensive than is warranted by the situation. The management decides what information is desired, the factory and work are investigated, the books of account are designed, and the installation is made gradually. Unless the cost records "tie in" with general books they are practically worthless. C. lists eleven books which will be involved in the general bookkeeping scheme: (1) the charge register records the invoices covering all purchases; C. explains how this is used, a typical form, which is reproduced being used for illustration; (2) the cash receipts book is explained in a similar manner. *Ibid.*, **10** [5], 176–78 (1927).—(3) The cash disbursement book is similar to the cash receipts book, but with different headings; (4) the petty cash account should be handled by the "Imprest System"; (5) the sales book is a simple record and consists of large sheets of paper suitable for use in a typewriter; (6) the journal is used mainly for adjusting and closing entries; unless the entries are numerous the ordinary journal containing a debit and credit column will be satisfactory; (7) the expense

distribution book is a very important one; the record is divided into departments and the departments into accounts; (8) the sales ledger may be the ordinary standard ledger form and will contain charges to customers and credits from customers; the same form can be used for a purchase ledger; (9) the general ledger may also be a standard form and will consist largely of control accounts; C. lists 29 principal accounts; (10) the credit memorandum book takes care of any returned goods or other credits. The postings will be made the opposite of the sales book postings. A.E.R.W.

Survey of clay-mining operations in N. J. WILLIAM C. KEMPF. *Ceram. Age*, **10** [4], 136–38 (1927).—A wealth of clay deposits exists in the Raritan River district of N. J. K. describes the history of their development and the geological reports which have been made on the district. The most extensive mines are located in the Woodbridge-South Amboy section. The principal method of mining is in open pits by hand, although steam, electric, and gasoline shovels are used wherever practicable. A description of the most important mines including those at Sayreville, Keasby, Woodbridge, and Perth Amboy is given. Clay mining is still active and strong and will continue so for some years to come. A.E.R.W.

Testing road-making material. ROGNAR SCHLYTER. *Tonind. Ztg.*, **51** [73], 1329–33 (1927). F.P.H.

Penfield hacking system. ANON. *Brick Clay Rec.*, **71** [8], 564–65 (1927).—A description of the Penfield hacking machine being installed as part of the Penfield system in the Denning's Point Brick Works at Beacon, N. Y., is given. This machine can be adapted to handle pallets of any length and containing any number of brick of any size within the range of those now used, and build these brick into units of any desired size. A capacity of from 150,000 to 200,000 brick per day can be taken care of; in addition to the elimination of hand-setting the brick, the mechanically hacked brick are more perfectly spaced and there is less chipping than with hand labor. E.J.V.

Manufacturing practice in firebrick industry. ANON. *Brick Clay Rec.*, **71** [9], 622–31 (1927).—The new plant of the Evens & Howard Fire Brick Co., at St. Louis, Mo., is equipped with everything in keeping with the modern trend in manufacturing practice: (1) modern equipment, (2) efficient layout, and (3) mechanical perfection of product. It is possible to ship as first quality brick between 97 and 99% of the 30 to 35M brick turned out daily and those brick that are shipped are of higher quality than those manufactured under old-fashioned conditions. A detailed description of equipment and methods is presented. E.J.V.

Building business. GEORGE RANSOM. *Brick Clay Rec.*, **71** [9], 634–36 (1927).—A description of the plant and methods of intensive selling and personal contact used by the Manchester Real Estate and Mfg. Co. of Epping, N. H., is given. H. C. Burrows took over this plant 3 years ago and is manufacturing "Star Brick." E.J.V.

Use of brick to prevent disintegration by acid waters. ROBERT F. FERGUSON. *Brick Clay Rec.*, **71** [9], 638–40 (1927).—Due to the action of acid waters on Portland cement, there is a general disintegration of walls or forms which are made of this material. Tests made on concrete, neat cement, and clay brick to determine their acid-resisting properties show that the brick is the best. The brick may be used with advantage and ultimate economy for construction work in the presence of acidified waters and for the protection of concrete masonry which is so exposed. E.J.V.

Market conditions affect Hudson River industry. WM. CRAWFORD HIRSCH. *Brick Clay Rec.*, **71** [11], 778–80 (1927).—A discussion of the economic conditions confronting the Hudson River brick industry following a 25% shrinkage in the market value of its product in the course of the past year. E.J.V.

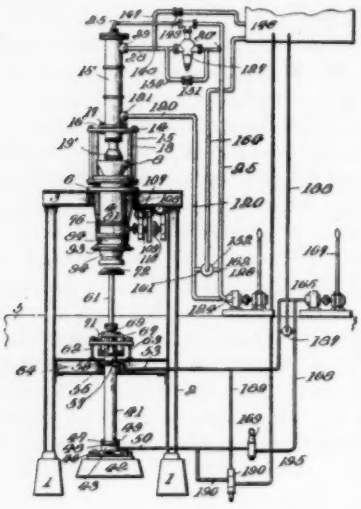
Selling face brick. F. C. SOLMS. *Brick Clay Rec.*, **71** [11], 782–84 (1927).—More face brick can be sold by building supply dealers it is believed, based on S.'s 18 years' experience in the manufacture of face brick, as a traveling brick salesman, and then as an exclusive face brick distributor in Detroit. E.J.V.

Cleveland Clay League exhibit. ANON. *Clay-Worker*, **88** [5], 349–51 (1927).—The Cleveland Clay League exhibit of brick panels illustrating different kinds of brick, bonds, joints, and colored mortars, in 2 very prominent locations in downtown Cleveland is described. E.J.V.

Factory design and equipment.. IX. T. W. GARVE. *Clay-Worker*, **88** [5], 352–55 (1927).—The development of plasticity is the general heading with the subheads (1) plasticity, (2) tempering, (3) machinery equipment, and (4) aging. The terms plasticity, tempering, and aging are defined and discussed. The pug-mill in several forms, wet pan, and other machinery used in development of plasticity of clays are discussed. For previous articles See *Ceram. Abs.*, **7** [1], 28 (1928). E.J.V.

PATENTS

Brick-sizing machine. SYLVESTER GOSS HAMER. U. S. 1,650,832, November 29, 1927. A brick-sizing machine including a sizing form, a yieldingly supported carriage, means for actuating the carriage to position bulk material in the path of the sizing form, means for actuating the sizing form to compress the bulk material on the carriage, thereby to depress the carriage and express surplus bulk material between the carriage and the form, and means for severing the expressed bulk material from the material within the form.



Hydraulic sewer-pipe press. THOMAS A. HIBBINS. U. S. 1,651,203, November 29, 1927. A hydraulic pipe press comprising a cylinder, a piston, a clay plunger carried by the piston, hydraulic means for causing the downward movement of the piston, and automatic means for causing a slowing down of the movement of the piston.

Refractories

Petrographic study of slags from boiler furnaces. SAMUEL J. MCDOWELL AND H. C. LEE. *Jour. Amer. Ceram. Soc.*, **11** [1], 35–41 (1928).—Observations are based on a microscopic study of the effect of slags, particularly those of an Illinois coal, on refractories. A mineralogical relation is shown between the slag and the refractory used. The principal phases present in a cooled slag are: (1) a plagioclase feldspar, (2) magnetite or hematite, (3) mullite with iron oxide in solid solution, (4) glass. The so-called "interface" between slag and refractory is largely crystalline upon cooling and consists principally of mullite which, surrounded by the slag, has grown from fine needles in the refractory to larger ones. In high alumina refractories where diaspore is present, the stained interface is much thicker and grains of corundum are formed. This zone of crystallization may be conducive to spalling. The effect of slags on various refractories is discussed.

Firing properties of refractory fireclay products. A. T. GREEN. *Trans. Ceram. Soc.* [Eng.], **26** [2], 110–130 (1926–27).—A survey of the fundamental firing characteristics of fire clays in relation to the industrial operation. In considering the effects of the firing operation three definite periods of importance stand out: (1) the water-smoking period, ranging in normal firing from ordinary temperatures to about 250°C; (2) the oxidizing period ranging from 500–850° approximately; (3) the vitrification range, from 800° to the finishing temperature. The time-factors required to complete these operations vary considerably with the nature of the clay and the design and manipulation of the kiln. Porosity determinations have been the mainspring of many investigations concerning the effect of heat treatment on the nature of clay products. Particularly is this so in connection with the vitrification. In many of the researches the rate of change of apparent porosity with temperature is taken as an indication of the rate of vitrification. This is a good indication, but to G. it seems that the rate of change of apparent porosity with temperature together with the rate of formation of sealed pores is a better criterion of the rate and extent of vitrification. Fire clay, as is indic ted in the porosity-temperature curves begins to vitrify at about 800°. At this temperature the most fusible silicates begin to melt or melting silicates are formed. These become more fluid with rise of temperature, and commence to dissolve other constituents, which often reduces the initial fluidity. Many physico-chemical phenomena, including the effect of eutectic mixtures and the formation of complex substances, are now brought into play, and these influence profoundly the physical properties and chemical constitution of the viscous mass. With fire clays generally, the rate of vitrification is slow up to to temperatures near 1200°, but the range of temperature during which the involved actions take place to any appreciable extent is a variable quantity. Constitutional changes taking place during the vitrification range, color changes, and time factors are also discussed. A bibliography of 34 references is given. R.F.S.

Use of Indian sillimanite. W. J. REES. *Trans. Ceram. Soc.*, [Eng.], **26** [2], 132–37 (1926–27).—The discovery and exploitation of large resources of natural sillimanite in India is of interest to the maker and user of refractory materials for exposure to very high temperatures. Attention has been drawn to its value as a refractory material for the construction of glass-melting pots and tank furnaces, rings, etc. The possibilities of its efficiency in contact with molten glass have been shown in some comparative tests. Small pots made of sillimanite and fire clay (pot clay) were placed in position in the working end of a tank furnace melting glass for electric bulbs, and inspection made when the fire clay pot had become very badly worn showed that the sillimanite pot was only slightly worn. Excellent results have been given with pot-rings made from sillimanite with 25 to 30% of plastic fire clay, with both lime-soda and lead oxide-potash glasses. Gates, skimmer-blocks, and other parts of feeding devices for molten glass made from sillimanite have also proved much more durable than similar articles made from fire clay. It is necessary to fire sillimanite refractories to higher temperatures than is customary with fire clay in order to get the best results from them. The minimum firing temperature for sillimanite articles, which are to come into contact with molten glass, should be 1300°C. One of the most successful uses to which sillimanite has been put is in the construction and repair of pot furnaces. The refractoriness of a sillimanite brick (15% clay bond) is shown. The sillimanite brick was heated for 6 hours at 1700°C in contact with a high-grade silica brick. The silica brick fused and flowed over the sillimanite brick, but there is no sign of fusion of the latter and no corrosion where the two bricks were in contact. Promising results are being obtained with sillimanite brick in the arches and walls of high-pressure boiler furnaces with normal coal-firing and also with oil and pulverized-coal firing. Very good results are also being obtained with sillimanite saggers and also with sillimanite shelves on the trucks of

tunnel ovens. The mechanical strength at high temperatures of well-fired sillimanite brick with 15 to 25% of fireclay bond is very good, being much superior to that of fireclay brick. R.F.S.

Testing and behavior of refractory material under stress at high temperatures. A. J. DALE. *Trans. Ceram. Soc.* [Eng.], **26** [2], 138–55 (1926–27).—In this paper, previous work by D. and others on the behavior of different types of refractory material under stress at high temperatures has been abstracted. Typical load-test results provided by silica and firebrick materials differing widely in constitution have been presented and discussed, and the industrial interpretations of certain of the findings have been suggested. The modified Mellor and Moore load test with an electric furnace, the behavior of silica materials under load at high temperatures, and grog effects are discussed. R.F.S.

Study of glass tank block. ANON. Bur. Stand., *Tech. News Bull.*, No. 127, pp. 10–11 (1927).—Data are given showing the effect of corrosion of molten glass on 2 clay blocks and on 5 so-called special refractory blocks. Andalusite, cast and natural mullite and sillimanite blocks were included in this test. R.A.H.

Load deformation test of fire brick. FRANZ KANHÄUSER AND JOSEPH ROBITSCHEK. *Sprechsaal*, **60** [38], 685–88 (1927).—The investigation of the deformation behavior of fire brick under load varies greatly between different testing laboratories. With the same materials the results may vary over a 200°C range. Specimens prepared with the same materials and using the same experimental set-up and conditions of tests show results varying over a range of 40°C. Causes of these discrepancies are being investigated with a view to eliminating them. R.A.H.

Study of sagger losses. ANON. *Ceram. Age*, **10** [4], 121 (1927.—A brief description of the Bur. Stand. investigation of saggers undertaken to reduce the excessive losses now sustained by potteries due to the short life of the saggers used in firing and glazing. A.E.R.W.

Water-cooled furnaces. LEITCH. *Combustion*, **17** [2], 89 (1927).—The design and development of the use of the water-cooled furnace walls in the plants of The New York Edison Co. and associated companies is outlined, the fin furnace being originated by one of its executives, Thomas E. Murray. The generic idea was not to reduce the upkeep cost of refractories but to entirely eliminate them. In the design of the water-cooled furnace careful attention given to circulation and expansion undoubtedly accounts for the success with which it operated from the beginning. Several photographs accompany the article. G.W.W.

Lining of a cupola. RUSSEL. *Foundry Trade Jour.*, **37** [582], 24 (1927).—The alternative methods of lining a cupola are (1) bricking and patching, and (2) ramming *i.e.* the production of a monolithic lining. The Refractories Dept. of Sheffield University has made exhaustive experiments and is preparing the details for a reliable standard mixture. R. concludes that monolithic linings are the best and that they should consist of a mixture of hard comparatively large refractory lumps as lumps of ganister, with a most refractory clay or other satisfactory binding material, carefully applied, dried, and used. G.W.W.

Design of fireclay shapes. E. H. VANSCHOICK. Amer. Refrac. Inst., *Bull.*, No. 16, Oct. 1927.—Some progress has been made lately in the standardization of the so-called standard shapes of fire brick. There are about 27 of these shapes, not including the circle brick, and they are all based on and are variations of the standard 9-inch straight, measuring $9 \times 4^1/_2 \times 2^1/_2$ inches. Since they are of standard size and shape, they are carried in stock by manufacturers and when used judiciously in construction work

will save much cutting of brick, thus making a better structure at lower cost. There is a second class of shapes, more or less standard, many items of which are carried in stock by manufacturers. The standardization of this class has not progressed as far as the first and there is room for further work along this line. In this class may be included several sizes of cupola blocks and cement kiln liners, a series of air furnace bung brick, open-hearth checkers and the $13^1/_2$-inch series which is based on the $13^1/_2$-inch straight and corresponds roughly to the 9-inch series mentioned above. While there can be no standardization of specially designed refractory shapes, there are certain general rules which can be applied to their design, which will be of much assistance to the manufacturer and will also tend to give the consumer a more satisfactory product. The most important general rule is, that if there is a choice of 2 or more designs for any shape or set of shapes, the design which is best adapted for successful manufacture will be the one that will give the best service in use. If the shape has been so designed that it is difficult to construct a mold which can be filled properly, such defects as folds, sand cracks, or spongy corners may result; or the proportions of the shape may be such that severe differential strains are set up in the drying and cracks develop at points of weakness. Even if the shape is satisfactory as far as the molding and drying are concerned, it still may not be possible to set it properly in the kiln, and warpage or firing checks will result. The extremely intricate or badly proportioned shape has thus been subjected to excessive strains or possible failure in any or all of the steps in its manufacture. If it does come through apparently sound and in good condition it is again subjected to stresses in use which are very liable to attack it at the same points of weakness which caused trouble in the manufacture. It is almost certain then to fail more rapidly than would the alternative design which could have been manufactured more easily. Under service conditions where resistance to spalling is important, small units give better service than larger ones. This is almost a corollary of the rule given above, although it is not usually of as much importance to the manufacturer as it is to the consumer. This rule is particularly applicable to the design of suspended arches, door arches, jambs and lintels, feed-hole blocks, etc. The internal stresses set up in fireclay shapes by rapid thermal changes are roughly proportional to the size of the individual pieces and failure occurs more rapidly in larger blocks when other conditions are comparable. Sharp corners on inside surfaces or sharp reëntrant angles are not permissible. Unavoidable cracks will develop at such points during drying and will be aggravated during firing. It is therefore necessary to fillet all such angles on the drawings, for if not so shown either the drawings will be returned for correction or the fillets will be added according to the best judgment of the manufacturer. The radii of the fillets should be as large as possible in every case.

F.P.H.

Gas-permeability of refractory brick for metallurgical furnaces. F. A. WICKERHAM. *Amer. Iron and Steel Inst.*, May, 1927; *Stahl u. Eisen*, 47 [40], 1674–76 (1927).—A description of the method and apparatus is given. The following results were obtained on various kinds of brick and show the dependence of gas permeability on pressure:

TIME (SEC.) FOR 28.317 L. AIR TO PASS THROUGH THE BRICK AREA OF SURFACE CONTACT 6.45 cm^2

Type of brick	Pressure 453.6 g.	Pressure 226.8 g.	Pressure 113.4 g.
Silica brick 6.35 cm. thick	188	376	745
Chrome brick 6.35 cm. thick	166	326	642
Magnesite brick 6.35 cm. thick	527	1046	2081
Clay brick 6.35 cm. thick, 5 best	625	1228	2433
Clay brick 6.25 cm. thick, 10 best	775	1531	

The gas permeability of various brands of clay brick and the influence of the method of preparation on the gas permeability are shown in table form. F.P.H.

Future progress of refractories. STUART M. PHELPS. *Blast Fur. Steel Plant*, **15** [12], 563–66 (1927).—The whole problem of advancement in the utility of refractories is of such a complicated and obscure nature that at times it appears hopeless. The manufacturer or user cannot solve the problem alone and it is only through the closest coöperation and critical study by each group that significant progress can be made. Maximum life of the refractories under a given set of conditions in service will be obtained only by employing brick that have the specific properties essential for that service. The properties of the brick that are to be purchased should be considered. This resolves itself into the use of specifications which should be an effective means of buying refractories. Experiences with specifications to date, however, have not always been satisfactory and a little thought will reveal the cause of this condition. Clay refractories are usually made of a mixture of flint and plastic clays. A wide range of properties can usually be obtained by blending various percentages of these clays. In addition to such mixtures various methods of manufacturing are employed to produce desirable characteristics in the brick. The immediate outlook for improved clays does not appear promising. Mention should be made, however, of the opportunity of purifying clays for use in manufacturing blast-furnace brick. The iron compounds present in nearly all suitable refractory clays are believed to be one cause of the disintegration occurring in these linings. Clays are treated for use in manufacturing glass-house refractories and many of the other ceramic industries employ processes for purification, such as weathering, washing, elutriation, and magnetic separation. The chemical composition of the various clays used in the brick must be of importance to their behavior in service. For instance, if clays are employed in a brick mixture that varies widely in the silica-alumina ratio and total percentage of fluxes, there will be, in the heat treatment of service, various chemical reactions occurring in these dissimilar constituents. A refractory cannot be expected to maintain its original properties in service under such conditions existing within the brick. Obviously dissimilar physical properties of the ingredients will have like effects. Such reasoning applies to all types of refractories and is not limited to clay refractories. Another field of possible improvement is that of the control of the percentage of the various particle sizes of the materials used in compounding the batch. A study of this subject is now in progress and preliminary data appear to be of value. It is well known by practical brick men that the structure of the brick is often more important than the chemical composition or resistance to heat. The structure of the finished refractory is not only dependent upon the process of manufacturing, but also upon the physical and chemical characteristics of the materials employed in compounding. Therefore, studies of the effect of calcined flint or plastic clay upon the brick should be conducted. The following types of refractories are discussed: (1) silica brick, (2) diaspore, (3) mullite, (4) chrome. Recent improvements and changes in the methods of manufacture of these various refractories are pointed out. Recent progress in the testing of refractories is described. F.P.H.

Preparation of refractory materials. WALTER OBST. *Feuerfest*, **3** [8], 129–30 (1927).—A survey is made of the latest patent literature pertaining to the preparation of various types of refractories. F.P.H.

Sillimanite-mullite problem. W. EITEL. *Feuerfest*, **3** [8], 130–31 (1927).—A discussion of the Al_2O_3–SiO_2 system and its importance to the glass manufacturers. F.P.H.

Refractory brick: preparation and properties of alumina, bauxite, magnesite, chromite, and silica brick. F. LEPERSONNE. *Rev. Univ. des Mines VII*, **15** [2], 76–82, [4], 166–71, (1927); *Stahl u. Eisen*, **47** [39], 1624 (1927). F.P.H.

Chemical investigation of refractory materals. I. H. J. VAN ROYEN. *Stahl u. Eisen*, **47** [41], 1696–97 (1927).—The methods of chemical analysis of refractory materials are explained. F.P.H.

Investigation of the slagging refractory material. HERMAN SALMANG. *Stahl u. Eisen*, **47** [43], 1816–20 (1927).—The action of acid, basic, and neutral slags on refractory materials is studied. The action of the various slags on clay crucibles is studied. The crucibles containing the slags are heated at various temperatures for various intervals of time and the results compared. The 26 slags have a wide range in composition. The chemical analysis and physical properties of the crucibles are listed. F.P.H.

Clay and clinker. HANS HIRSCH. *Tonind. Ztg.*, **51** [73], 1316–18 (1927). F.P.H.

Influence of fuels on life of refractory materials. ANON. *Iron Trade Review*, **81,** 141–42 (1927); *Feuerfest*, **3** [8], 137 (1927). F.P.H.

Plastic refractory materials in furnaces. W. OSENBERG. *Centralblatt der Hütten u. Walzwerke*, **30** [30], 317–19 (1926).—The coming into prominence of the plastic refractories in America and the forms in which they are available on the market are discussed. Methods of repairing furnace walls and overhanging arches, heating of tamped walls, cooling, shrinkage on drying, resistance to breaking out of the material, testing of the materials, and costs are taken up. E.J.V.

German graphite: importance and winning. W. LANDGRAEBER. *Centralblatt der Hütten u. Walzwerke*, **30** [35], 369–70 (1926).—The methods of extracting the graphite in Germany, preparing the material for commercial use, and applications thereof in many fields are taken up. E.J.V.

Mycalex: a new insulating material. ANON. *Chem. and Ind.*, **46,** 1130 (1927).—The G. E. Co. has developed this new insulating material, composed of ground mica and lead borate. It is of additional interest in that it utilizes fine mica waste, (previously 95% of all mica mined). H.H.S.

Magnesia refractories for steel furnaces. G. M. CARRIE AND C. F. PASCOE. *Can. Mining Met. Bull.*, No. 186, 1186–1272 (1927).—A discussion of uses, properties, comparison with other refractories, application in steel furnaces, and service in operation. (*C. A.*)

Analysis of high-alumina clays and refractories. W. SINGLETON. *Chem. Age* (London), *China Clay Trade Review Sec.*, **17** [420], 6; [425], 6–7 (1927).—Details of procedure are given, with slight modifications of well-known methods. (*C. A.*)

Mullite refractories. A. A. WURGAFT. *Keram. Steklo*, **3,** 27 (1927).—The preparation of mullite from cyanite, bauxite, and diaspore, and its properties are discussed. Its high refractoriness and mechanical strength render it suitable for glass furnaces. (*T.E.C.S.*)

Bauxite studies. H. HARRASSOWITZ. *Metall Erz*, **24,** 181 (1927).—The term "bauxite" covers two kinds of rocks which differ chiefly in water-content: bauxite in the restricted sense consists mainly of monohydrated alumina in the gel form, laterite mainly of crystalline alumina in the trihydrated form. The general name "alite" is given to all rocks consisting of hydrated alumina. In the older formations laterite may be transformed into bauxite. Bauxites associated with chalks always lie uncomformably on deposits formed under subaerial conditions, and are therefore of continental origin, as is shown in the Bihar mountains. In the Karst area only chemical and not mechanical erosion was possible, and the bauxite material infiltered slowly into the chalk. (*T.E.C.S.*)

Testing fireclay material. W. PECHTOLD. *Sprechsaal*, **59,** 376 (1926).—The properties dealt with include macro- and micro-structure, deformation under load, resistance to spalling and chemical action. Re-fired bricks were also tested. (*T.E.C.S.*)

The fusibility of clays and the van't Hoff formula. W. SCHUEN. *Tonind. Ztg.*, **50,** 1643 (1926).—It is shown that the van't Hoff formula for the melting points of salt solutions is probably applicable in full to the melting-points of clay mixtures. The higher the melting point of a refractory brick and the greater its heat of fusion, the better the brick. Silica bricks can be considerably improved by careful choice of bond and by avoiding the use of too much clay. (*T.E.C.S.*)

BOOK

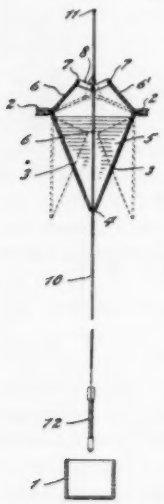
Materials for the Investigation of Russian Graphite. Akad. der Wiss. Leningrad. 136 pp. 10 illustrations; *Feuerfest,* **3** [8], 135 (1927). F.P.H.

PATENTS

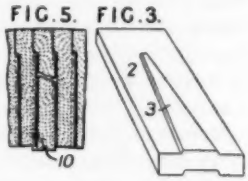
Zirconia-faced refractory. PAUL G. WILLETTS. U. S. 1,650,577, November 22, 1927. A refractory body having a facing of substantially pure zirconium oxide that is partially interpenetrated with the body and is therefore united integrally with it.

Multiple graduating machine. HANS N. HALVORSEN. U. S. 1,650,831, November 29, 1927. In a graduating appliance of the character described, the combination of means to support the ware, means to apply spaced graduation lines on the ware while thus supported, and means to apply legends automatically on the ware while thus supported at positions corresponding to those of a plurality of such graduation-lines.

Brick-molding process and apparatus. CRAWFORD ZIEGLER. U. S. 1,651,571, December 6, 1927. The process of molding material which comprises segregating a batch of plastic material, dropping the batch unconfined into a mold, and guiding the batch to prevent it from turning while it is falling.



Furnace brick. L. S. LONGENECKER. Brit. 278,070, November 23, 1927. Integral blocks or tiles, for furnace roofs and other purposes necessitating interlocked blocks are provided with a retaining portion offset from the plane of the adjacent face and widening progressively from the top of the block to the bottom. In the illustrated form, blocks or tile (2) are interlocked by triangular projections (3) engaging similarly-shaped recesses in the adjacent block with a slight clearance so that in the event of a block breaking, it falls slightly as shown at (10) Fig. 5, but cannot become detached from the roof. The edges (5) of the projections and recesses are made slightly wedge-shaped and the corners are rounded to facilitate molding. The projections and recesses are used with the apex uppermost.



Refractory bricks, etc. F. L. DUFFIELD. Brit. 278,120, November 23, 1927. Bricks made by molding under pressure a fused or sintered mass of dolomite or magnesite are allowed to cool in the molds after removal of the shape-forming pressure. Fluxes such as ferricoxide, clay, or slag may be added to the basic material; the temperature employed may be 1200–1700°C; steel or cast iron molds may be used.

Refractory crucibles. BRITISH THOMPSON-HOUSTON CO., LTD., Brit. 278,367, November 23, 1927. The pores of a fireclay crucible are filled with carbon by impregnating it with coal tar pitch and gradually baking, the treatment being repeated if necessary. Impregnation may be effected in vacuo.

Production of ceramic masses. DEUTS. TON- & STEINZEUG-WERKE A.-G. Ger. 441,944, November 15, 1925. The addition of powdered ferro-silicon to ordinary ceramic masses improves the mechanical properties and the resistance to temperature changes of fired articles made from the mixture. (*C. A.*)

Terra Cotta

Firing open terra cotta kilns with gas. W. O. OWEN. *Jour. Amer. Ceram. Soc.*, **11** [1], 42–45 (1928).—Experiments conducted with a small kiln in firing terra cotta without the use of a muffle giving satisfactory results, the large kilns at this plant were equipped for gas firing, the muffles being removed. The equipment for gas firing is described and alterations made in the kilns are explained. The general operation of the kilns is discussed and savings enumerated. Gas as a fuel in the ceramic industry is recommended.

Determination of acid resistance of ceramic products. O. KALLAUNER. *Sprechsaal*, **60** [40], 727–28 (1927).—A method by Kallauner and Barta for the determination of acid resistance of stoneware plates is given together with data showing the effect of digestion of the sample with a solution of soda previous to test as against no such digestion. The original article published in the above journal in 1921, did not take such a digestion into account. R.A.H.

Ceramic plastic architecture. ANON. *Tonind. Ztg.*, **51** [69], 1211–13 (1927).—Examples of recent work along this line are illustrated. F.P.H.

Importance of roofing tile in building problems. PAUL SCHULTZE. *Tonind. Ztg.*, **51** [72], 1289–90 (1927). F.P.H.

Principal conditions for absorbing production of roofing tile. ANON. *Tonind. Ztg.*, **51** [72], 1291–92 (1927). F.P.H.

Roof and roofing tile. ANON. *Tonind. Ztg.*, **51** [72], 1292–93 (1927).—The following subjects are discussed: (1) shelter for the house, (2) German structures, (3) the cement industry as a model, (4) quality workmanship. F.P.H.

Clay-roofing tile, its purpose and opponents. F. WIECKER. *Tonind. Ztg.*, **51** [72], 1293 (1927). F.P.H.

Firing roofing tile. A. NAWRATH. *Tonind. Ztg.*, **51** [72], 1293–94 (1927).—Description of type of kiln and method of placing the tile in the kiln as used in Germany. F.P.H.

History of interlocking roofing tile. WILHELM LUDOWICI. *Tonind. Ztg.*, **51** [72], 1297–1300 (1927).—A description of various types of interlocking roofing tile and presses used in making this tile. The plant of Carl Ludowici in Jockgrim is described. F.P.H.

Recent patent literature pertaining to roofing tile. ANON. *Tonind. Ztg.*, **51** [72], 1300–1302 (1927).—A survey is given of the German patent literature pertaining to roofing tile. F.P.H.

Tests for determining quality of roofing tile. ROGNER SCHLYTER. *Tonind. Ztg.*, **51** [73], 1323–24 (1927).—The following tests and properties are used to determine the quality of roofing tile: (1) general properties such as color, degree of vitrification, structure, dimensions, slope, condition of surface, weight on delivery and after drying, density, (2) water permeability, (3) water absorption, (4) freezing test, resistance to the action of frost, (5) cross-breaking and impact strength. The methods of carrying out these tests are described and the results obtained on a number of tile are presented in diagrams. F.P.H.

General notions on the glazed earth ware. L. DELOYERS. *Bull. soc. chim. Belg.*, **36**, 55–63 (1927).—An address. (*C. A.*)

White Wares

Earthenware, brown earthenware, and art pottery industries. PAUL JÜRGEL. *Keram. Rund.*, **35**, 26 (1927).—A plea for coöperative buying and selling among small potteries producing different types of ware. H.I.

German whiteware industry in 1926. H. LEWE. *Keram. Rund.*, **35**, 35–38, 59–61 (1927).—A discussion of economic conditions in the porcelain and whiteware industries. H.I.

Ceramic glazes and enamels. B. M. PEARSON. *Ceram. Age*, **10** [3], 92–98 (1927).—After describing the characteristics which good ceramic glazes must posses, P. discusses the methods used in preparing the raw materials for application to the ware. Fritting enables all chemical action to be completed outside the glazing furnace, provides homogeneity in the glaze, and converts all the ingredients into forms which are insoluble in water. P. discusses several designs of frit kilns and their characteristics. Glazes are used for coating earthen ware, porcelain, tile sanitary ware, domestic earthen ware, and metals. In the latter case they are generally termed enamels. Glazes can be divided into the leadless and lead types, opaque, colored, and clear transparent glazes. They may be applied directly to the body or on a white or colored engobe; in the latter case the glaze is usually transparent but may be colored. Qualities of and recipes for the following glazes are given: clear, lead, leadless, opaque, tin opaque, zinc opaque, phosphoric acid opaque, fluorine opaque, white opaque, antimonial opaque, zirconium opaque, and glazes for brick, tile, etc. A.E.R.W.

B. and O. Railroad depicts its progress on china ware. ANON. *Ceram. Age*, **10** [3], 101–103 (1927).—The B. and O. Railroad has designed and produced pictorial china ware and glass tumblers in commemoration of the 100th anniversary of the founding of the road. This ware tells the history of the progress of the railroad in pictures in a way to impress every traveller on the line. In the various borders of the ware, which is a special line of blue colonial ware, the evolution of motive power on the railroad is set forth in historical sequence. The scenes within the borders include historic Harper's Ferry, the Potomac Valley, the Cheat River, Indian Creek, the Narrows at Cumberland, the Carrollton and Thomas Viaducts. The manufacture of the ware is described in detail; two years were required; the copper plates were engraved by hand, 16 large coppers being required. The engravings were printed on thin rice paper and the wet print placed on the dish to be decorated, which had previously been molded and bisque fired. The design was then transferred by rubbing, somewhat like decalcomania, after which the paper was washed off and the dish was ready for glazing and firing. While new in texture, the new china follows closely the style of the old Staffordshire. It was a difficult task to fire this ware to the temperature necessary to develop the strength of good dining car china and at the same time prevent the blue color from running and blurring the pattern. A.E.R.W.

Effects of sulphur on pottery glazes. FRIEDRICH DETTMER. *Sprechsaal*, **60** [37], 667–68 (1927).—The effect of the sulphur content in fuels makes itself disagreeably apparent on glazes in 2 ways, (1) in oxidizing atmosphere at red heat through formation of sulphates which are the basis for crazing, corrosion, pinholing, and scaling; (2) in reducing atmosphere before formation of silicates, the formation of sulphides as polysulphides which are the basis for greenish, yellowish, and brownish discolorations in the glazes. It causes bubbles and devitrification in colored glazes. R.A.H.

Building of matrixes in the ceramic industry. LOUIS SACKLOWSKI. *Sprechsaal*, **60** [39], 703–705; [40], 728–30; [41], 745–47; [42], 765–67 (1927).—Both original and redesigned types of molds and dies for pressing articles used in electrical construction are discussed. R.A.H.

European potters crowd market. ANON. *Ceram. Ind.*, **9** [6], 680 (1927).—Germans make determined effort for larger share of market. Imports of decorated table, toilet, or kitchen ware of china and porcelain from the various European countries for the period July 1 to Sept. 30, 1927 are shown. F.P.H.

Technical advances in the white ware industry in 1926. W. STEGER. *Keram. Rund.*, **35**, 1–5, 20–22 (1927).—The results of technical and scientific investigations and discoveries in the field of porcelains, china, and white ware are summarized. H.I.

The Bohemian porcelain industry. BENNO SCHMIDT. *Keram. Rund.*, **35**, 45–46 (1927). H.I.

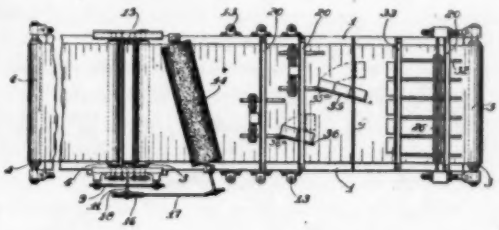
Standards for floor and wall tile. ANON. *Tonind. Ztg.*, **51** [69], 1214–17 (1927).—German industrial standards DIN Nos. E1398, E1399, E1400 covering this type of material are given. F.P.H.

Czechoslovakian potteries. F. MORRALL. *Pottery Gaz.*, **52** [606], 1899–1901 (1927).—The methods adopted in the making of feldspar china and English bone china are contrasted. Round saggers and setters are produced by jolleying, while the square and oblong are die-pressed. The principal decorating method used in the cheaper factory was lithography. The types of kilns used, packing of the ware, and conditions of labor in the cheap factories are discussed. E.J.V.

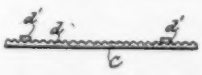
Steatite porcelains. LADISLAUS VON PUTNOKY. *Chem. Rund. Mitteleuropa Balkan*, **3**, 66–69; *Chem. Zentr.*, II, 1321 (1926).—Steatite products from the pure powder must be baked at 1450°, whereas a thick object in which there is also 15–30% clay and water can be baked at 1200–1300°. Such products can be manufactured more cheaply than ordinary porcelain products, shrink less, and possess great elasticity. Products intermediate between pure steatite and steatite porcelains can also be made. (*C. A.*)

PATENTS

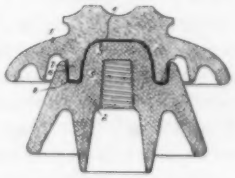
Tile-fettling machine. MYRON J. SOUTHWICK. U. S. 1,648,966, November 15, 1927. In a tile-fettling machine the combination with a movable support for conveying tile before it is fired, of a plurality of fettling devices for acting upon opposite edges of the tile passing between, means for turning a row of tile simultaneously to dispose their fettled edges transversely to the path of movement of their support, and additional fettling members adapted to act upon the untrimmed edges of the tile.



Machine for cleaning tile and analogous objects. HARRY D. LILLIBRIDGE. U. S. 1,649,604, November 22, 1927. In a tile-cleaning machine, tile-feeding mechanism embodying a conveyer composed of relatively flexible material provided on the load-engaging surface thereof with corrugations, and cleats unitary with the conveyer and spaced thereon, the cleats protruding beyond the surfaces presented by the corrugations.

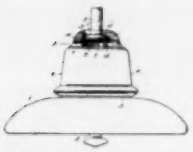


Sectional insulator. JOHN M. PECK. U. S. 1,649,853, November 22, 1927. An insulator comprising a plurality of nested sections, a projection on one section fitting into and being guided and centered by a corresponding recess in another section, an annular rim surrounding the recess of the other section, the rim fitting into a corresponding annular groove in the 1st section, a resilient cement interposed between projection and recess, a layer of resilient cement on the annular rim, and a nonresilient cement on the sides and bottom of the annular



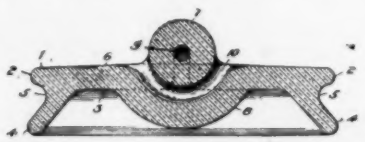
groove, the resilient cement and the nonresilient cement forming one continuous and unbroken film for uniting sections throughout their central areas.

Insulator. DAVID H. OSBORNE. U. S. 1,650,034, November 22, 1927. In a high tension insulator of the suspension type, a body of insulating material, a metallic cap thereon, the cap having a recess with a closed bottom, the top of the cap being formed with opposite radial slots and a lateral radial slot intersecting the 1st-named slots at the center, a suspension element formed as a bolt having a disklike head adapted to be inserted through the 1st-named slots when in tilted position whereby the bolt may be arranged to extend at the axis of the body, the recess having a substantially vertical wall at the outer end of the 2nd-named slot, the wall being engageable by the edge of the disk to limit lateral movement in one direction.



Manufacture of tile. VICTOR LEFEBURE. U. S. 1,650,080, November 22, 1927. A tile produced at temperatures below 350°C from a silicate constituent with fillers in the plastic form, and an oxide, in combination with a backing of asbestos cement, to which the tile is secured by a joining agent between the tile and the backing.

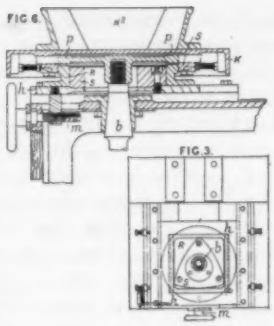
Insulator. MINOR F. H. GOUVERNEUR. U. S. 1,651,201, November 29, 1927. (1) An insulator comprising a disk of dielectric material each face of which is perforated by openings leading to a separate circular passage interlinked in the body of the disk, and the dielectric thickness of said disk at all points adjacent the passages being substantially constant. (2) An insulator comprising a body portion of dielectric material provided with interlinked passages and a plurality of projections disposed upon opposite sides of the body and crossing each other.

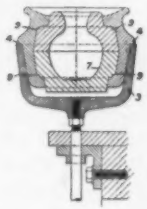


Means for securing vitreous articles in place. CORNELIUS J. RUKENBROD. U. S. 1,652,052, December 6, 1927. In means for securing vitreous handles to oven doors the handle comprising a pair of spaced single piece pedestals and a single piece hand grip supported thereby, each pedestal having but one cavity, which extends across the pedestal and in from one side only, and an opening extending longitudinally through the pedestal from the base to the bottom of the transverse cavity. The hand grip is provided with a projection on each of its ends extending into the tranverse cavity of the respective pedestal and has an opening adapted to be aligned with the longitudinal opening in the pedestal; a threaded locking element adapted to be placed in the opening in said hand grip, prior to the placing of the hand grip projection into the tranverse cavity of the pedestal; and a securing screw adapted to be passed through an aperture in the oven door, through the longitudinal opening in the pedestal, and engaging the threads of the locking element in the hand grip.

Jolleying pottery. E. JOHNSON, C. FARR, AND B. BOULTON, LTD. Brit. 277,045, November 2, 1927. In shaping oval and other noncircular articles of pottery by jolleying, an oval or other motion of the holding chuck is produced through the medium of two sets of slides running at right angles to one another, and capable of initial adjustment relative to a rotating spindle to vary the shape of the article produced. In the illustrated form one of a series of nonrotating members (*S*), selected to suit the particular shape of article to be produced, is bolted to a sliding plate (*h*) adjusted on the framing by the hand screw (*m*) relatively to the mold spindle (*b*). A hollow frame (*R*) rotates round the member (*S*), and has a sliding connection with adjustable guides (*s*) on the chuck (*K*). The latter has a second sliding connection in a direction at right angles to

the former, with a plate (p) fixed on the mold spindle (b). The chuck (K) carries the mold carrier (K^2), which is provided with one or more flats to prevent relative movement between the carrier and the plaster mold. In a modified form the hole in the member (R) is octagonal.





Pottery molds. E. SADLER. Brit. 277,271, November 2, 1927. A horizontally divided 2-part plaster mold (7, 9) is encased in a vertical-divided metal container (4) which is shaped externally to fit the jigger head (3) and internally to fit the outer surface of the mold. A shoulder (4) limits the downward movement of the container. When the container and mold are lifted bodily from the jigger head after the jolleying operation is completed the container is removed at once for re-use.

Casting teapots, etc. C. BAILEY AND H. TAYLOR. Brit. 268,129, March 26, 1926. Four-part molds for casting teapots complete with spout and handle are provided with auxiliary mold recesses for casting accessories such as the cover, cover knob, spout plug, and perforated grid. (*T.E.C.S.*)

Molding handled ware. ECLO MANUFACTURING CO. AND A. L. LEIGH. Brit. 268,220, Sept. 11, 1926. An undivided outer die is provided with body and handle recesses, and is formed with a transverse opening to receive a draw pin adapted to form the handle opening. The inner die is provided with a rim-forming part and with a detachable, radial portion to form the upper part of the handle. (*T.E.C.S.*)

Making handled pottery. J. BAILEY AND FURNIVALS, LTD. Brit. 268,268, Jan. 14, 1927. A one-piece mold has a small, detachable handle portion formed in two or more parts. A roughly-shaped clay handle is inserted in the recess of this separate portion before it is pushed into position in the main mold. The article is formed by jolleying, and is removed together with the handle portion from the main mold as a unit, the handle portion of the mold being subsequently removed by a lateral movement. (*T.E.C.S.*)

Making handled pottery. C. F. BAILEY. Brit. 267,454, Jan. 21, 1927. Jugs, cover dishes, mugs, etc., are formed by jolleying the body and part of the handle in a mold having handle recesses. During the usual jolleying operation the slip is forced a certain distance into the handle recesses, and the handle is completed by pouring slip through a hole provided at the top of the handle recess. (*T.E.C.S.*)

Equipment and Apparatus

New developments in combustion apparatus in 1927. ANON. *Combustion*, **17** [6], 367–78 (1927).—A review of the outstanding new features as visualized by the manufacturer. (1) Bacharach Industrial Co: A portable electric CO_2 and temperature meter, is a new development in the gas analysis field. It consists of a precision profile indicator, a variable resistance for current adjustment, a bridge zero adjustor and a tumble switch. With the tumble switch in the upper position, the precision indicator becomes an ammeter, enabling proper current adjustment for top mark deflection. Three standard dry cells are enclosed in the instrument for current source. With the switch in the center position the instrument can be used for gas analysis of a flue gas. The gas is sampled with a hand aspirator which draws the gas through a small $CaCl_2$ and cotton filter, which, when not in use is held in the cover of the instrument. Continuous indications for short periods (2 to 3 hrs.) can also be obtained by means of a simple water aspirating device. With the switch in the downward position, temperature measurements can be

read, the thermocouple being connected to the binding posts on the instruments. The readings are converted from the millivolt scale to temperature by the use of a temperature millivolt curve. (2) Bernitz Furnace Appliance Co: In keeping with the increasing use of water-cooled walls in the place of boiler furnace refractories this company has developed the Bernitz Carborundum Water Wall Blocks (Thayer type). By covering water wall tubes on the fire face with these blocks the resulting construction offers a wall, (*a*) that supports combustion right up to the face of the wall, (*b*) that maintains high furnace temperatures at all ratings, (*c*) that resists both flame and mechanical abrasion. The design and arrangement of the supporting means are unique and substantial and an absolute contact is had between the tubes and the blocks. Expansion is properly taken care of. (3) The Brown Instrument Co. describes a visible record multiple recording pyrometer for measuring and recording the temperature of flue gas. This type of instrument simultaneously records flue gas temperatures from a number of operating units on a single continuous chart, is economical and convenient because it makes a comparison of flue gas temperatures from the different units easy and accurate. There is a minimum of delay before the latest addition to the record becomes visible. This new visible type multiple record continuous chart recording pyrometer has a special ribbon shift which provides an unobstructed view of the latest addition to the record line every 30 seconds. This instrument can be supplied to record from 1 to 12 records simultaneously on a single continuous chart. The chart roll used with the recorder lasts approximately two months before renewal is necessary. (4) The Cambridge Instrument Co., Inc., describes the Cambridge combustion control, which is a progressive step-by-step master control which in accordance with the steam pressure regulates dampers, fans, stokers, and all auxiliary appliances having any part in the firing. It is adjustable to any desired pressure limits and maintains the correct combustion conditions at all times. The control ignores the small changes in pressure which are self-adjusting. Just as soon as a predetermined variation in pressure takes place, the control makes a definite adjustment to gain produce normal conditions. The control settings are fixed to suit the individual conditions of each installation. (5) Drake Non-clinkering Furnace Block Co. describes the S.X. air-cooled wall as a radical departure from previous construction offered in the line of air-cooled walls. Designed with proper regard to the principles of heat transfer, a highly preheated air is obtained while the face of the tile is kept at a low temperature; consequently slagging and spalling are eliminated and the nemesis of all wall construction deformation loading, is eliminated without resorting to complicated supports. (6) Charles Engelhard, Inc., has announced a new CO_2 and stack temperature instrument called the "Stackmeter." The CO_2 and temperature records are produced on one chart in two colors: the black record indicates the percentage of CO_2, and the red record, the temperature of the stack. The gas analyzer incorporates many new features, the most outstanding of which is the method used to protect the platinum heating elements. The platinum wires are inserted in fused quartz jackets which not only mechanically protect them from vibration, but also prevent gases from coming in contact with the wire. Erratic readings are therefore eliminated. Other features are the clean-out plug on the cell enabling the operator to clean out the cell when desired, the improved flow gage, and the extreme simplicity in the apparatus. It operates on the well known thermal conductivity principle as introduced by the Bureau of Standards. (7) Erie City Iron Works: In order to improve conditions at both ends of the combustion range, the Seymour Furnace, a refractory covered water wall or water-cooled refractory wall has been introduced. The water tubes in such a furnace wall provide a barrier beyond which the refractory may not melt down, and at the same time the refractory provides a protection against tube failures by keeping the flame and furnace radiation from

coming in direct contact with the tube surface. Maximum furnace temperatures are provided for at all ratings and also exceptionally long refractory life. (8) The Gifford-Wood Co. describes and pictures a car unloader. This machine is an especially designed flight conveyer, with a long flat tail, to extend across the rails under the hopper of a bottom dump car and to feed the coal onto the tail end of a portable conveyer for delivery to truck or stock pile. All sizes and grades of coal, as well as coke, from slack up to 16-in. lump are handled at an average capacity of 60 tons per hour. The car unloader consists of a double chain flight conveyer contained in a steel body mounted on an adjustable truck, and driven by an electric motor. The conveyer is 18 in. wide and is made up of 2-in. steel channel flights mounted every 12 in., between two strands of $1^1/_2$-in. pitch heavy steel roller chain. The full width of 18 in. is available for pushing the coal. The flights travel over a continuous $^3/_{16}$-in. steel plate on which the coal drops. The flights moving over this plate push the coal before them out from under the car hopper and up a short incline to the delivery end where it is discharged onto the loading end of another conveyer. (9) The Peabody Engineering Corp. describes a non-stratifying large capacity pulverized coal burner. To burn large quantities of pulverized coal, a burner must accomplish at least one thing, it must diffuse the coal into the combustion chamber in such a manner that each particle is surrounded by sufficient air for complete combustion. Unless this is done effectively stratification will be noted in the flame. This company has developed the new Toronto Burner to accomplish this purpose. In this burner coal is fed tangentially into a screw-thread-vaned burner barrel and is given a whirling motion into the furnace by a blast of combined primary and secondary air. (10) The Ranarex CO_2 indicator and recorder, made by the Permutit Co., is simple, of an entirely mechanical principle and of rugged construction and is well adapted to severe operating conditions. Some of the improvements made on the Ranarex machines during the past year are: The parts and passages in contact with the flue gases have been simplified and made more readily accessible for inspection. New filtering equipment has been developed and is shown by a figure. A porous tube filter, located inside the flue, very efficiently filters the gas and keeps the suspended matter out of the pipe line. This filter is mounted by means of a special wall sleeve. A permanent connection to a compressed air line allows for convenient and quick cleaning of the filter by back-blowing. The moisture which condenses from the gases upon cooling is collected and automatically drained in the water-legs. Before entering the Ranarex the flue gas passes through a secondary filter filled with steel wool. This filtering equipment has proven to be superior to any other method of filtering the gas sample for the Ranarex and thus substantially contributes to the reliable operation of Ranarex machines. (11) The recent development by the Geo. P. Reintjes Co. of a refractory arch to span over door openings of furnaces and to be used for the roofs of the smaller furnaces without the use of structural steel has attracted attention because of its simplicity and its novel features. Two tile shapes are used for spans up to 6 feet width of opening. A third shape forming a trussed arch is used beyond that width. The height of the arch blocks is equivalent to 3 courses of brick, eliminating the cutting of the well-known levelers encountered in all sprung arches. The width of each tile is the same as the brick course. The key tile is the skewback inverted. The door jambs can be splayed outwardly or the arch roof raised in steps for seeing into the interior corners of the furnace without modifying the tile shapes. This arch has been successfully installed in cracking stills, baffle walls in continual carbonizing furnaces, malleable iron furnaces, roofs of heat-treating furnaces, dutch ovens of horizontal return tubular boilers, and rear arches of horizontal return tubular boilers. Reintjes Flexible Corner Bonding Tile, which is patented, has been recently developed to eliminate the common faults of corner construction. This tile provides ample clearance for expansion at the

corners. It also ties together the side and end walls, preventing the common fault of the front wall falling inward. It can also be placed in the side wall at intervals to take care of expansion needs. The expansion joint is provided either by parting of the tile, or clipping with trowel the end of one tile, which is illustrated. This bonding tile is the thickness of one course of brick and serves as a starting brick for each course. The joints break at each succeeding course and form a perfect corner of the inner 9-inch refractory lining. The tile in each course overlaps the next lower course further strengthening the structure. The tile is developed for use when the brick are set in the solid header or quarter bond patterns. Two corner bonding tiles displace three brick and one soap. G.W.W.

New developments in brick manufacture. ANON. *Eng. News-Record*, **98** [15], 631 (1927).—Asphalt brick for bridge floors and grade crossings, made from natural rock asphalt pressed at approximately 300°F is made by the Asphalt Brick Co., of St. Louis, Mo. It is claimed that the melting point is higher and that a higher penetration is obtained with these brick than with artificially mixed asphalt because the volatile oils are absent, and because of the character of the aggregate of the natural rock asphalt. This brick is particularly adapted for bridge floors. Special sections are made for grade crossings to fit between the flange and head of the rail. G.W.W.

New developments. ANON. *Eng. News-Record*, **98** [12], 507 (1927).—A ball-bearing vibrating screen is announced by Link-Belt Co. of Chicago, and is adaptable to any kind of fine screening work. The operating mechanism is very simple, consisting of a single shaft riding in oversize ball-bearings. Adjustable counterweights throw the shaft out of balance and cause the screen box to vibrate. It is made in 5 sizes. The feed hopper vibrates with the screen box, uniformly spreading the material over the screening surface. G.W.W.

Regulating and controlling devices for ceramic processes. ANON. *Ceram. Ind.*, **9** [6], 647–51 (1927).—Reactions and conditions occurring in ceramic processes and a brief description of what is happening in kilns, furnaces, smelters, driers, leers, etc., that may affect the quality of the ware or the efficiency of the process are given. The various controls required in the 3 stages of the firing of clay ware are described. The removal of moisture is summarized in 3 stages: (1) The removal of pore water from the surface of the ware, the water being carried to the surface by capillary action. The bulk of the shrinkage occurs in this period. (2) Removal of water clinging to the pore walls by bringing the drying medium into direct contact with the moisture. (3) Removal of the hygroscopic and chemically combined water in the kiln during the water-smoking period. The advantages of humidity control of drying are pointed out. The necessity of proper methods of control in the following process is stressed: (1) melting of glass, (2) annealing of glass, (3) smelting enamels, (4) firing enamels, (5) manufacture of producer gas, (6) oil burning systems. F.P.H.

Application of control devices in the ceramic industries. ANON. *Ceram. Ind.*, **9** [6], 651–58 (1927).—Some practical demonstrations are given of applications of control devices in ceramic plants. Actual experiences are given of the value and need for regulating or measuring equipment. The placing of thermocouples in periodic and tunnel kilns is discussed. The number of thermocouples required in the various kilns is given. The annealing of sheet glass requires very exact temperature control and the leer is equipped with 35 to 40 base-metal elements. These couples are arranged to show the temperature on the top of the plate at each edge and at the center of the glass sheet. They are inserted through the crown and extend to within a few inches of the glass surface. Through the annealing range in the leer the couples are spaced about 5 feet apart. This space is increased as the glass cools below 900°F. It is essential to vary the length of the annealing range according to the thickness of the glass and the

speed of the movement through the leer. As the glass emerges from the coal end of the leer it is examined for strains. This is done by having a polariscope constructed in such a manner that light underneath the entire width of the sheet is reflected from a polished black glass surface through the sheet and then reflected by a mirror placed above the sheet at such an angle that it can be viewed through a telescope containing a Nicol prism. This examination will show if any part of the plate is not of the proper temper and with the very complete temperature record obtained, any undue strain found can immediately be corrected. Control instruments recommended for use on gas producers are described. The following instruments and their use are described: (1) automatic regulating valves, (2) flow meters, (3) carbon monoxide and carbon dioxide meters, and (4) control instruments on ball mills. F.P.H.

Description of various control instruments. ANON. *Ceram. Ind.*, **9** [6], 658 (1927). —The following instruments are described. (1) Automatic control of furnace temperatures using electricity or liquid or gaseous fuels as heating agents. (2) Pump and compresser regulators. (3) Pressure gages. (4) Draft gages. (5) Reducing valves. (6) Shut off valves. (7) Flow meters. (8) Carbon dioxide recorders. (9) Pyrometers, thermoelectric, radiation, and optical pyrometers. (10) Thermometers. (11) Vapor tension instrument. (12) Hygrometers. F.P.H.

Driers for refractory products. OSWALD HELLER AND ERNST STRUNK. *Feuerfest*, **3** [8], 125–29 (1927).—The following subjects are discussed: (1) the present-day drying in factories, (2) information concerning average drying time for various types of products, (3) possibility of shortening this time, (4) physical fundamentals of the drying of ceramic products, (5) drying with moist air, (6) division of drying into the beginning and true drying period, (7) method of circulating air with constant change of air, (8) Heller's method of circulating air using a condenser, (9) heat sources for drying, (10) drying diagrams. The drying time required for glass pots was shortened from 6 months to 14 days by the use of methods proposed by H. and S. F.P.H.

Determination of the dust-forming portions of materials. F. H. ZSCHACKE. *Sprechsaal*, **60** [37], 668–69 (1927).—Description of an apparatus of simple construction for use in determining the per cent of dust in batch materials. Sieve-cloth having at least 5000 meshes to the sq.cm. is used in conjunction with an air current. R.A.H.

Works transport from economy view-point. H. J. POOLEY. *Chem. and Ind.*, **46**, 1064–77 (1927).—Survey of the appliances available for handling material in clay and chemical plants, with numerous photographs of electric capstan, electric ram, automatic railway, electric telphers, cable dray scraper, skip elevator, tilting bucket, conveyer, mixer-conveyers, band conveyers, pan conveyers, vibrator, combination telpher and traveling crane, electric traveling hoist, spiral chute, ash dischargers, and chain grab. H.H.S.

BOOK

Pyrometry. W. P. WOOD AND J. M. CORK. 207 pp., 93 illustrations. New York: McGraw-Hill Book Co., 1927. Price $3.00 postpaid. The final chapter is on refractory materials used in pyrometry. The book treats of the accurate measurement of high temperatures, and the construction, operation, and uses of pyrometers and thermometers. H.H.S.

PATENT

Drive for a rotary press. Ger. 435,461; *Rock Prod.*, **30** [23], 79 (1927). The patent refers to heavy machinery such as sand lime-brick presses, called upon to furnish large outputs and exposed to great wear. A pinion gear at the flange of the revolving table is set in motion by a spur gear revolving in the same direction. The latter is operated by another gear located along its axis. The latter transmits a straight line motion to a number of bolts fitting into corresponding openings at the inner circumference of the

spur gear. The housings of both gears are made as long as possible to secure accurate adjustment of the two gears for a long time. The driving power is distributed uniformly over the circumference of the spur gear. F.P.H.

Kilns, Furnaces, Fuels, and Combustion

Discussion on "Kiln Construction." T. W. GARVE. *Jour. Amer. Ceram. Soc.*, **11** [1], 32–34 (1928).—Discussion on "Kiln construction. An efficient round downdraft kiln for firing refractories," by J. B. Lyon, printed in *Jour. Amer. Ceram. Soc.*, **10** [3], 185–204 (1927).

Tunnel kiln development in the ceramic industries. I. PHILIP D'HUC DRESSLER. *Ceram. Age*, **10** [3], 81–91 (1927).—The first effort in the development of tunnel kilns dates back 150 years or more, but it was not until the 20th Century that industrial conditions were favorable to its introduction or that adequate mechanical parts, electricity, or refractories were available. The different types were developed in the order direct-fire muffle, and regenerative direct-fire. In the first muffle kilns the muffle was tied into the construction of the kiln and was disintegrated by heating and cooling. Then Conrad Dressler developed a kiln in which the muffle was independent. D. explains the construction and operation of this kiln fully with the help of diagrams. In the Dressler type the action is downdraft throughout the heating and soaking sections. This method of heating permits a very high temperature of combustion without overheating the goods and is therefore very efficient. In many cases less than 1% excess oxygen will be found in the exhaust gases. D. describes the development and construction of the modern Dressler kiln, especially the muffle unit. A modern well-built kiln should operate for at least five years without interruption. Only 30% of the heat applied to the kiln in the form of fuel is not recovered. Enough can be recovered from the exhaust gases to complete the drying of crude clay products. The rest of the article is devoted to a description of the construction and operation of kilns for sanitary ware, terra cotta, brick and tile, glass pots, and for metallurgical uses. The design and method of loading of the cars is given special consideration and illustrated. **II. Direct-fire kilns.** *Ibid.*, **10** [4], 122–30 (1927).—Direct-fire kilns have been studied for a much longer period than muffle-type kilns. They did not have much success until the beginning of this century, due to poor cars, overheating of cars, and inadequate methods of heat distribution. Bock, in Germany, built 40 or 50 kilns before this time but nearly all were later abandoned. A tunnel type, direct-fire kiln is analogous to a horizontal chimney, the gases being introduced at the center and pulled out at the ends. Faugeron designed the first relatively successful coal-burning kiln of this type in Europe, in which the tendency of the hot gases to accumulate at the crown was counteracted by sloping the crown at intervals. In the United States we have been more successful because the natural gas and oil available at reasonable prices have enabled us to subdivide our fire boxes and, moreover, to put our fuels under pressure and give them a directional force. Very satisfactory kilns have been developed, although D. does not believe they permit as much control as the muffle type. He explains their operation by means of a plan. As the gases tend to flow between the load on the cars and the side walls and crown, there is an inclination at the present time to use positive mechanical means to obtain good preheating of the centers of the cars at the entrance of the kilns. Various other problems are discussed in detail, including recuperation in the cooling zone and avoiding hot spots at the burner points. A few typical installations are then described and shown in photographs. These include a typical direct-fire kiln using producer gas with oil as a secondary fuel, a coal-fired kiln, loaded cars in a fire brick and a face brick kiln, the first tunnel kiln built in America, and a new cross-fire type kiln. The cross-fire type kiln can be built with a greater cross-section than the longi-

tudinal type of kiln but makes recuperation of the heat of the outgo in gases difficult unless regenerative kilns are used. The latter are a recent development, one type using recuperators and the other using regenerators. A short discussion follows. A.E.R.W.

Discussion of kilns and kiln firing. ANON. *Ceram. Age*, **10** [5], 165–73 (1927).—A staff report of the New Jersey Clay Workers Association Meeting at Trenton, Oct. 26–27 (1927). A further report giving detailed data will appear in the next issue of *Ceramic Age*. A.E.R.W.

Production and use of petroleum coke. L. A. MEKLER. *Fuels and Fur.*, **5** [12], 1637–40 (1927).—M. discusses the operation of coking and cracking stills, the analysis and physical properties of petroleum coke, and its use in cement kilns, smelting and refining, on grates and stokers and in ceramic kilns. Petroleum coke has been used on a large scale to fire cement kilns, about one ton of coke being sufficient to make 20 barrels of cement. Petroleum coke could be used very profitably in the ceramic industry, the absence of ash being quite an advantage. By mixing with coal, a great range of flame characteristics can be obtained. Powdered coke makes possible very clean atmospheres at much higher temperatures, and requires less air preheat. It is thus suitable for firing special refractories. The limited supply of coke would allow only local applications, but plants situated near a source can often use it economically. A.E.R.W.

Insulation of a pottery oven. T. SIMPSON. *Trans. Ceram. Soc.* [Eng.], **26** [2], 156–57 (1926–27).—Complete insulation of an earthenware glost oven, 19 ft. 6 in., using a dome diatomite brick, 9 x 4½ x 3, as the insulating material has been done. The oven was newly constructed on ordinary lines, with a few improvements, and is of the cone type. The insulation has been built as a free lining, and is not bonded in any way to the common or refractory brick work. The crown has been built with a higher dome than usual, and insulated with a 2½-inch dome diatomite brick placed flat on top of the brick work. The bottom is insulated under the flue seatings. The results of this experiment show at least a 20% saving. By insulating the oven it was possible to construct much thinner walls, thereby increasing the capacity. It is easier to cool the oven because the heat does not penetrate into the walls to any extent and is cut short at the insulation; therefore there is not the heat contained to be gotten rid of. By applying special dampers it is possible to draw the oven the day after it is fired. This oven has been fired a considerable number of times, and up to the present shows no signs of cracking of the common brick work or bulging of the refractory. The oven bottom and crown are perfect. The time of firing and cooling is reduced; the capacity is increased; there is a saving in fuel, and there is apparently no difference in the sagger loss. The cost of construction is a little more than building an oven in the ordinary way, owing to the fact that the insulation does away with at least a 9-in. brick, which must be taken against the cost of the diatomite, added to which, approximately 50% extra capacity is obtained for this cost, which means that to build an oven to contain the same capacity would cost considerably more than is so in this case. R.F.S.

Flat "arch" for continuous kilns. ANON. *Brit. Clayworker*, **36** [427], 225 (1927).—A kiln of this type has been in satisfactory service for 2 years The advantages of this type of roof are: (1) no thrust is put on the external walls, due to weight or expansion of the roof under heat thereby permitting thinner walls; (2) the roof has a rectangular cross-section, a shape convenient for setting goods in the upper part and assisting uniformity of firing goods; (3) replacements in roof on account of repairs easy and simple. A brief description of construction is given. R.A.H.

Passage of solid particles through cylindrical kilns. J. D. SULLIVAN, C. G. MAIR, AND O. C. RALSTON. Bur. Mines. *Tech. Paper*, No. 384.—Empirical formulas have

been presented so that the time of passage of solid particles through rotary cylindrical kilns can be calculated. Correction factors for nose rings or constrictions have been added. For a given kiln the formulas given, together with the apparent density of the material to be used, the rate of feed, and simple formulas of trigonometry and geometry, enable one to calculate other kiln factors, such as volume of material in the kiln, depth of bed, length of chord, and capacity. In the simple kiln equation there are 6 variables; if any 5 are known, the other can be determined. R.A.H.

Reactions in gas producer and regenerative chamber from the physico-chemical viewpoint. W. BRASS. *Sprechsaal*, **60** [38], 689–90; [39], 708–10; [40], 732–34; [41], 747–49; [42], 767–69 (1927).—A review of the physico-chemical fundamental laws followed by a discussion of the purpose of the gas producer and regenerator and the carbon-oxygen system and how it operates in this connection. R.A.H.

Setting up a heat balance for a coal-fired ceramic kiln with periodic operation. W. STEGER. *Ber. deut. keram. Ges.*, **8** [4], 224–34 (1927).—Four methods of evaluating ceramic kilns are described. The distribution of heat in a ceramic kiln is discussed. The data necessary to calculate the heat balance of a kiln are pointed out and detailed methods of collecting this data are described. The methods of calculating are illustrated by examples. The amount of heat required to heat 1 kg. of substances from 20 to t°C is summarized in the following table.

t=	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400
Raw clay substance	16	37	60	86	119	241	293	333	386	420	455	489	525	560
Sand	15	37	60	85	118	145	173	201	231	262	292*	322*	355*	390*
Feldspar	13	29	47	68	92	117	143	172	202	241	281	310	345*	380*
Raw porcelain	15	34	55	81	110	193	220	248	286	331	380	428	478	528
Fired porcelain	15	35	57	80	107	135	167	205	253	308	363	416*	473*	528*
Raw white ware	15	33	54	76	103	169	196	218	247	284	335	388	441	
Fired white ware	15	35	57	80	107	175	187	194	259	301	351	397*	442*	
Sagger, fired clay and 10% free quartz	16	36	60	84	117	138	166	196	228	271	311*	359*	399*	431*

* Extrapolated values. The specific heats for the various kiln gases are given. F.P.H.

Gas producer giving efficient service. R. M. CHATTERTON. *Blast Fur. Steel Plant*, **15** [12], 573–74 (1927).—A description is given of the Koller gas producer which is widely used at present in Europe. The particular feature of this producer is the type of grate which is so constructed as to adapt the producer to the utilization of low grade fuels. About 400 Koller producers have been built and installed in Central Europe during the last 4 years. The construction and operation of this type of producer are given in detail. F.P.H.

Continuous tunnel kilns installed in silica brick plants. ANON. *Min. and Met.*, **8** [252], 534 (1927).—Harbison-Walker Refractories Co. has announced that continuous tunnel kilns will be installed in its five plants, the plans for which call for ultimate displacement of all old round-type periodic kilns. The reconstruction of the East Chicago works alone, the first to be affected, involves the expenditure of some $1,500,000. It is stated that the practicability of this method for the firing of silica brick on a commercial basis was thoroughly tested out in Germany at the plant of the H. Koppers Co., several hundred tons of ganister rock, the raw stock for silica brick, being shipped overseas to Düsseldorf and made up into American type brick under the direct supervision of Harbison-Walker technical and operating staffs. As a result of the tests, the company secured exclusive rights for the Koppers type of kiln in the U. S. The first kiln to be erected is producer gas fired on the regenerative principle. It will have a total length of some 500 ft. Green brick are run into one end of the kiln on cars, and emerge at the other end ready for shipment. One such kiln has a daily capacity of

35,000 nine-inch brick, considerably over 100 tons. In operating the kiln, pyrometer control will be used. The burning temperature will be 2700°F. On completion of the three units in East Chicago, the new method of operation will be extended as fast as practicable to the other Harbison-Walker plants at Pittsburgh, Mt. Union, and Downingtown, Pa., and Birmingham, Ala. F.P.H.

Amount of building material required to construct a Hoffman kiln. ANON. *Tonind. Ztg*, **51** [69], 1210 (1927).—The material required to construct a Hoffman kiln with a daily production of 12,500 brick is calculated. F.P.H.

Pulverized coal firing. ERNST NATHO. *Tonind. Ztg.*, **51** [81], 1481 (1927); *Rock Prod.*, **30** [24], 98 (1927).—Pulverized coal was introduced in Germany in about 1900 following the American practice as a method of firing rotary kilns. Karl v. Forel, Fellner and Zeigler Co., and the Polysius Co., Dessau, used this method of firing. Such disadvantages as high fuel consumption, heat losses, formerly blocking the way of the rotary kiln, have been done away with since the advent of waste heat utilization, and pulverized coal is now definitely established in the German cement industry. The conditions of use of pulverized coal for boilers are somewhat different. The economic depression of post-war years produced frantic efforts to cut down wasteful methods, so pulverized coal was resorted to by many German manufacturers and American installations were copied without regard to the special conditions of native industries. Yet American practice differs essentially from that in Germany. The radiation effect on the refractory lining was reduced by enlarging the firing space to dimensions unknown in Germany, the pulverized coal flame was blown directly on natural corundum, the boiler being heated only by radiation. No very fine grinding was necessary there. In Germany few new installations are being built at the present time, but quite a few old plants are being adapted to pulverized coal firing. The space is naturally limited, so a coal pulverizer design with this in view is being marketed under the name of the Mindoga "Resolutor," consisting of a mechanical feeding device, a hammer crusher and an air separator. The shaft is strong enough to withstand shocks and is provided with ball bearings. The output of the "Resolutor" varies from 100 to 10,000 kg. per hour, with a moisture content of from 10 to 14% when preheated air is used. The fineness of the product is 2 to 10% on the No. 100 sieve or 5 to 25% on the 190 sieve. Power consumption is 12 to 18 H.P., all from one motor. F.P.H.

An efficient carburizing furnace of the surface combustion type. A. E. WHITE AND E. R. MCPHERSON. *Trans. Amer. Soc. Steel Treating*, **10** [6], 941–53 (1927); *Feuerfest*, **3** [8], 132 (1927). F.P.H.

Progress in gas producer practice. WM. B. CHAPMAN. *Glass Ind.*, **8** [12], 289–91 (1927).—The agitation of producers at both the top and the bottom of the fuel bed is discussed. Data on installations of Chapman agitators in different European gas producers are presented. The desirability for water-cooling jackets on producers is discussed. Higher rates of gasification with great uniformity of gas composition are possible. The water jacket also prevents clinkers from adhering to the side walls. Regulating devices used on producers include pressure regulators for maintaining constant pressure in the gas main, recording thermometer for the mixture of air and steam in the blast, recording pyrometer for the temperature of the gas leaving the producer, U-tubes for indicating the pressure of gas above the fire-bed or in the gas main, and a steam gage. A discussion of producer gas from coke and oil is given. Experiments by the British Government in using gas producers for boiler heating are taken up. E.J.V.

The rotary kiln and its operation. SCHUSTER. *Chem. Ztg.*, **51**, 666–67, 708–10, 727–28 (1927).—S. discusses the methods of feeding, refractory linings, accumulation of deposits on the walls of a kiln, the foundation, etc. In most modern practice the kiln

is inclined at a gradient of 4–5% with the horizontal. It is built widest at its mid-section (calcination zone) to permit thorough and uniform heating of the charge before it enters the hottest zone. To dry a new kiln requires at least 8 days heating with a small fire. On the last day the temperature must be kept above 100° to prevent condensation of water vapor. Gas and oil are replacing coal firing. (*C. A.*)

BOOKS

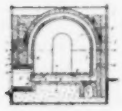
Flame and Combustion in Gases. WILLIAM A. BONE AND DONALD T. A. TOWNSEND London and N. Y. Longmans, Green & Co., 1927, 548 pp. $12.00. F.P.H.

Manual of Fuel Technology. H. STRACHE AND H. ULMANN. 471 pp. 22M. (1927.) Franz Deuticke, Leipzig und Wien. Reviewed in *Tonind. Ztg.*, **51** [72], 1307 (1927). F.P.H.

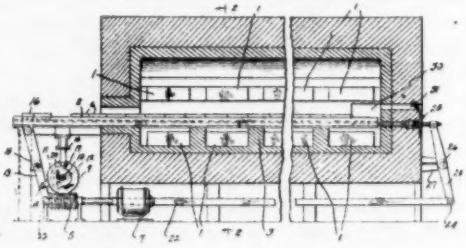
The Tunnel Kiln and Its Application in the Brick Industry. G. BENFEY. 2.4M. Max Janecke, Leipzig (1927). *Feuerfest*, **3** [8], 136 (1927). F.P.H.

PATENTS

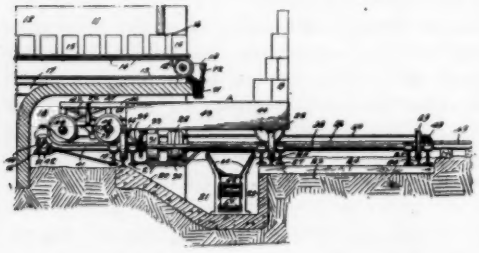
Kiln. ABEL HANSEN. U. S. 1,649,029, November 15, 1927. In a kiln, the combination comprising double floors and walls, arched over the top, the walls having a plurality of fire holes in the side with partition walls forming flues extending from the fire holes across the kiln under the kiln floor, then vertically up the farther side between the walls, then diagonally over the top of the kiln and vertically down the other side, then again across under the kiln floor in lines intermediate the fire holes and a longitudinal stack tunnel with which the flues finally connect.



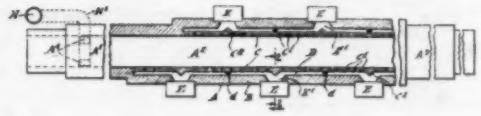
Conveyer. ALFRED RUCKSTAHL AND RUEL T. CADWELL. U. S. 1,649,926, November 22, 1927. In a window sash, a rear clamping member and a front clamping member, a bracket member in interlocking engagement with the rear clamping member and having a passage-way therein transverse to the plane of the glass and opening toward the front clamping member, a draw plate interlocking with the front clamping member and having an arm extending into the passage-way, means connected with the bracket for drawing the arm into the passage-way, a supporting member having a surface beyond and parallel with the edge of the glass in the sash, and a stiffening member fitting closely within the passage-way and engaging the top, bottom, and side walls and directly secured to the supporting member.

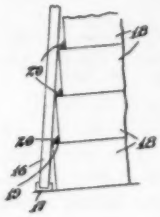


Mechanism for handling building blocks. HALVER R. STRAIGHT. U. S. 1,650,053, November, 22, 1927. In combination, a drier, a ware bearing conveyer adapted to carry ware through the drier and to deliver it to one end, a kiln car for receiving the delivered ware, means for supporting the kiln car beneath the discharge end of the ware bearing conveyer, an auxiliary car having a platform level with the top of the kiln car, means for locking the auxiliary car and kiln car together, means for imparting lateral movement to the auxiliary car, and means for imparting longitudinal movement to both cars.



Open fire kiln. PHILIP D'HUC DRESSLER. U. S. 1,651,380, December 6, 1927. In an open fired tunnel kiln provided with fire boxes distributed along the length of the firing zone portion of the kiln at each side of the latter, the improvement which consists in walls between the goods pathway through the kiln and side walls and uniting with the latter to form chambers receiving the heating gases from the fire boxes, the 1st-mentioned walls being formed with perforations in their lower portions distributed along a substantial portion of the length of the kiln through which the major portion of the heating gases pass into the lower portion of the pathway.

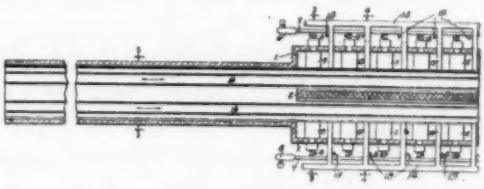




Method of firing brick. CLAUDE E. FULLER. U. S. 1,651,814, December 6, 1927. The improved method of firing brick which consists in arranging the courses of brick in tiers, insetting them as the number of courses is increased to form a ledge at each tier, placing combustible material on the ledges thus formed inclosing the kiln with scoving, whereby, as the heat of the fire increases, the layers of combustible material will be ignited and the outer tiers of brick in the kiln uniformly fired.

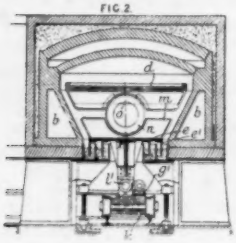
Rotary kiln and cooler. JOHAN S. FASTING. U. S. 1,652,168, December 13, 1927. The combination with a rotary kiln having an open end, of a relatively fixed burner's protective hood in front of the kiln, a kiln closing hood movably mounted within the protective hood for movement toward and from the end of the kiln, beams pivotally supported by the protective hood, means also supported by the protective hood to vary the inclination of the beams, a trolley mounted on the beams, the kiln closing hood being supported by the trolley for movement toward and from the kiln.

Tunnel kiln. WILLIAM LEE HANLEY, JR. U. S. 1,652,570, December 13, 1927. In a tunnel kiln, the combination of a duplex firing chamber having 2 firing zones separated by a vertical longitudinal partition wall and provided with rows of furnaces located on opposite sides of the duplex firing chamber, the furnaces of each row communicating directly with the adjacent firing zone, means for withdrawing the products of combustion from each firing zone, a unitary tunnel section extending longitudinally from each end of the duplex firing chamber, provided with parallel goods conveying means movable in opposite directions, each of which passes through one of the firing zones, each end section forming a combined cooling and preheating zone.



Furnaces; ovens. J. E. POLLAK. Brit. 278,207, November 23, 1927. In an annular rotary hearth furnace or oven for drying, distilling or gasifying loose material in a thin layer, the charge-conveying structure comprises an upper charge support or hearth (*d*) and a lower part including the supporting, driving, and seating means for the hearth, the 2 parts being spaced such a distance that the hearth proper can be subjected to heat from below. The hearth (*d*) is preferably made of heat-conducting material while the ring (*e*) carrying the seating-means (e^1) is made of or coated with insulating material. The ring (*e*) is preferably narrower than the hearth, as shown, so

that the latter can be more effectively subjected to radiation from the side flues (*b*).



The hearth (*d*), the ring (*e*) and the truck structure are connected by hinge members (*o*, l^1) so that the parts can suitably adjust themselves during rotation. The upper hinge member consists of a pair of rollers (*n*, n^1) mounted in seatings (*m*, m^1) fixed to the ring (e^1), and bearing-members, (*p*, p^1) fixed to the hearth (*d*), the pairs of elements being spaced to accommodate a radial rib (*o*) on the hearth. The trucks or bogies (*k*) are connected by a rim (g^1) formed as one of the driving-gear elements. Two or more ovens may be arranged concentrically within a single structure, and may be used for different stages of a process, *e.g.*, drying or firing, provision being made by which the material and the heating gases can be transferred from one oven to the next. The hearths of the concentric ovens may be driven in unison.

Geology

Some investigations of a Nebraska clay. ARTHUR JAMES RYMES. *Jour. Amer. Ceram. Soc.*, **11** [1], 46–60 (1928).—A brief review of the literature on the fluxing action of different metallic oxides on clays is given. A series of mixtures of what seemed to be the "dirtiest" clay of four obtained, with varying amounts of pure calcium carbonate which passed a 150-mesh screen was made up into briquets and physical properties were studied on the unfired and fired specimens. The firing was done at four temperatures, 1800, 1900, 1950, and 2000°F. Properties observed were fusion point, drying and firing shrinkage, crushing strength, and porosities of the fired specimens. The principle of the Armstrong volumeter used for porosity determinations is explained. The results obtained indicate possibilities of materially improving qualities of brick now being produced from so-called ordinary clays but only after a very considerable amount of further work is done.

Fullers' earth in 1926. JEFFERSON MIDDLETON. Bur. Mines, *Mineral Resources of the U.S.*, No. 2, p. 2, July, 1927. R.A.H.

Fluorspar and cryolite in 1926. HUBERT W. DAVIS. Bur. Mines, *Mineral Resources of the U.S.*, No. 2, p. 4, Aug., 1927. R.A.H.

Bauxite and aluminum in 1926. JAMES M. HILL. Bur. Mines, *Mineral Resources of the U.S.*, No. 1, p. 6, Sept., 1927. R.A.H.

Barite and barium products in 1926. R. M. SANTMYERS AND A. STOLL. Bur. Mines, *Mineral Resources of the U.S.*, No. 2, p. 7, Sept., 1927. R.A.H.

Clay in 1926. JEFFERSON MIDDLETON. Bur. Mines, *Mineral Resources of the U.S.*, No. 2, p. 14, 1927. R.A.H.

Physical properties of commercial English china clays. ANON. Bur. Stand., *Tech. News Bull.*, No. 127, p. 11 (1927).—Data are given showing the effect of variation in firing from cones 3 to 23 of 17 English china clays on the volume shrinkage, porosity, bulk specific gravity, and modulus of rupture. R.A.H.

Bauxite deposits of the southern states. G. I. ADAMS. *Economic Geology*, **22,** 615–20 (1927); *Min. and Met.*, **8** [252], Index 18 (1927). F.P.H.

Genesis of the uraniferous deposits of Kasolo (Katanga). R. VAN AUBEL. *Nature*, **120,** 714 (1927) from the meeting of Fr. Acad. Sci., Oct. 3, 1927.—Cubic uraninite is considered to be a pseudomorph. H.H.S.

Bentonite. H. S. SPENCE. *Sprechsaal*, **59,** 183–86 (1926); *Chem. Zentr.*, **II,** 96 (1926).—A review of the chemical composition, physical properties, and the applicability of the clay formerly termed "taylorite." (*T.E.C.S.*)

BOOK

Useful Minerals with the Exception of Ores and Coals. B. DAMMER AND O. TIETZE. 2 vols., vol. I, 554 pp., price bound 35.4M. Fred. Enke, Stuttgart (1927). F.P.H.

Chemistry and Physics

Production of refractory articles from tungsten powder. ANON. *Keram. Rund.*, **35,** 25 (1927).—A résumé of work by Harden (*Chem. Met. Eng.*, **33,** No. 9), Mennicke (The Metallurgy of Tungsten, 1911) and Williams (*Compt. Rend.*, **126,** 172 (1898)) giving methods of making heat-resisting crucibles, cylinders, etc., and their physical properties. Tungsten crucibles are very satisfactory for use as muffles in high frequency induction furnaces. H.I.

Measurement of absorption. K. SCHACHTSCHABEL. *Ann. d. Physik*, **81,** 929–51 (1926); *Sci. Abs.*, **30,** 376 (1927).—Detailed description with results from 17 glasses and 2 Pt films of a photographic method of measuring absorption. D.E.S.

Electrolytic conductivity with high-potential fields. H. SCHILLER. *Ann. d. Physik*, **83,** 137–52 (1927); *Sci. Abs.*, **30,** 775 (1927).—Measurements with direct current were made on glass by mounting a thin-walled bulb in a beaker and placing a solution of Na_2SO_4 on the outside and inside. The conductivity is purely electrolytic and not electronic. D.E.S.

Electrostatic charge on glass floats in very dry liquids. H. V. A. BRISCOE, P. L. ROBINSON, AND H. C. SMITH. *Phil. Mag.*, **3,** 63–64 (1927); *Sci. Abs.*, **30,** 420 (1927). D.E.S.

Thermal conductivity of vitreous silica with a note on crystalline quartz. G. W. C. KAYE AND W. F. HIGGINS. *Roy. Soc. Proc.*, **113,** 335–50 (1926); *Sci. Abs.*, **30,** 299 (1927).—Results obtained on vitreous silica at temperatures from 60–240°C show a linear relation between thermal conductivity and temperature. Values in (c.g.s.) units range from 0.00330 at 60°C to 0.00364 at 240°C with a mean increase of 0.00000185 per degree C. Conductivity of quartz crystal for heat flow parallel to the optic axis is 0.222 at 68°C and 0.0186 at 104°C. For heat flow perpendicular to the axis the values are 0.0129 at 70°C and 0.0116 at 105°C. D.E.S.

Polymorphism of silicon dioxide and the structure of tridymite. R. E. GIBBS. *Roy. Soc. Proc.*, **113,** 351–68 (1926); *Sci. Abs.*, **30,** 457 (1927). D.E.S.

Ultra-red absorption spectrum of didymium in glasses and solutions. ANON. *Zeit. f. Physik*, **39,** 391–401 (1926).—The absorption spectra of different ground glasses and solutions containing didymium, neodymium, and praseodymium chlorides, were measured between 0.7 and 2μ. The bands for the glasses were also found for the solutions. D.E.S.

Ultra-red absorption of colored glasses and salt solutions. T. DREISCH. *Zeits. f. Physik*, **40,** 714–24 (1927); *Sci. Abs.*, **30,** 376 (1927).—The glasses examined contained Fe, Cu, Cr, Co, Ni, and U as coloring agents. Salts of these metals were used in solution. The absorption bands of corresponding glasses and solutions were in the same form and positions unless formation of colored complexes disturbed the system. The ultra-red spectrum can be used for identifying coloring metals in glasses. D.E.S.

Absorption of quartz and quartz glass below 4.1μ. T. DREISCH. *Zeit. f. Physik*, **42,** 426–27 (1927); *Sci. Abs.*, **30,** 755 (1927).—The bands of quartz near 2.9μ show 3 maxima at 2.91μ, 2.97μ, and 3.02μ. In place of these bands quartz glass shows a simple narrow band at 2.75μ which is very intense. Quartz and quartz glass each show a narrow band at 3.75μ. D.E.S.

Acid processes for the extraction of alumina. G. S. TILLEY, R. W. MILLAR, AND O. C. RALSTON. Bur. Mines, *Bull.*, No. 267.—Review of previous work using nitric and hydrochloric acids for conversion of silicates to aluminum oxide. Sulphuric acid

decomposition of clay was experimented with and several new methods of treatment were devised for the purification of aluminum sulphate solutions. R.A.H.

Rôle of carbon in bodies in firing vitreous ware. M. MIELDS. *Sprechsaal*, **60** [35], 631–32 (1927).—Six reactions involving C, H, and O are used in discussing the possible actions of C in the furnace. Data are given to show that the critical temperature of decarburization ranges between 900° and 1100°C and that it is not necessary to force large amounts of air into the furnace at any time for oxidation of the carbon but to permit a gradual influx of air with increase of temperature of the furnace. R.A.H.

Determination of small amounts of magnesium in the presence of excess of ammonium salts. (Determination of magnesium in Portland cements.) O. KALLAUNER; J. SIMANE, AND B. HELAN. *Trans. Ceram. Soc.* [Eng.], **26** [2], 86–87 (1927).—During the year 1926 a series of investigations was carried out in the Silicate Research Department of the State Institute of Technology, Brno. The results of this investigation are as follows: For the precipitation of small quantities of magnesium (in the form of magnesium ammonium phosphate) in the presence of excess of ammonium salts, the Schmitz method is not suitable. This also applies to other methods of hot precipitation. It is therefore essential to use the cold method. Dilute solutions should be enriched in magnesium, either by evaporation or by adding a known weight of magnesium salts. It is only necessary to remove the ammonia partially or entirely if it is present in large excess. The solutions should be well mixed and finally filtered after a sufficiently long period (at least 24 and preferably 48 hours). To precipitate magnesium in the analysis of Portland cement, the normal German method is suitable in practice. Only when working with very small quantities of magnesium is it necessary to prolong the settlement of this precipitate from 24 hrs. to at least 48 hrs., and to mix the solution thoroughly. R.F.S.

Liquid immiscibility in the system FeO-Fe_2O_3-Al_2O_3-SiO_2. J. W. GREIG. *Amer. Jour. Sci.*, **14** [84], 473–84 (1927).—A part of the cristobalite field in the three component system FeO-Fe_2O_3-SiO_2 was investigated and the results are presented in graphical form. Mixtures of silica and iron oxide with a ferrous: ferric ratio of about 1:1 have a greater range of immiscibility than has been found in any other case. It has been found that the amount of alumina necessary to cause a single liquid to result from the melting of the mixtures varies with the silica content and with the ferrous-ferric ratio; a maximum of $6^1/_2\%$ being necessary in the case of ferrous: ferric ratio of about unity. G. discusses the application of his work to silica refractories as follows: "The silica brick from which the roofs of open hearth steel furnaces are built take up iron oxide in use. At the same time the original lime and alumina, in the form of a siliceous liquid, migrate between the grains of silica toward the cooler portions of the brick in front of an advancing liquid high in iron oxide. The brick thus becomes zoned, with a composition and structure corresponding to the original brick at the outside, followed by a zone in which there is a concentration of lime and alumina, and then by a part much higher in iron oxide. In the acid furnace this iron oxide commonly amounts to between 20 and 25%. Tests have shown that the temperatures of melting of the parts high in iron oxides are not far below those of the original brick and are often higher than those of the much more siliceous portions in which the alumina has concentrated. This is readily understood in the light of the equilibrium studies presented. Suppose the brick to have a ferrous-ferric ratio of 1:1. Analyses give a much lower ratio but they are made on brick that have been very slowly cooled in air and certainly oxidized. A mixture of silica and iron oxides with this ratio containing 65% iron oxide is completely liquid only at 1665°C. Any other mixture up to 95% silica with the same ferrous: ferric ratio is completely melted at the same temperature. If the mixture were 95% silica the ratio of crystals to liquid would be 40 to 25 immediately below that temperature, and at lower temperatures

still greater. The introduction of alumina, however, rapidly lowers the temperature of complete melting, and, since the composition of the liquid in equilibrium with cristobalite becomes at the same time rapidly more siliceous, the ratio of crystals to liquid is much lower at any given temperature. Since it is this ratio that determines whether or not the brick will stand, the behavior of the brick is seen to be exactly what is to be expected from the conditions of equilibrium. It may be worth while to draw attention to the fact that the addition of iron oxide to a mixture of silica and alumina may raise the temperature of complete melting; *e.g.*, consider the mixture Al_2O_3 5.5, SiO_2 94.5 which is completely liquid at 1545°C. To this add iron oxide and heat so as to form a mixture FeO 17.8, Fe_2O_3 17.8, Al_2O_3 3.54, SiO_2 60.8. From the results reported it can be seen that such a mixture will become liquid (2 liquids) at some temperature well above 1597°C, probably about 1625°C." F.P.H.

Elutriation velocity and grain size. R. RIEKE AND L. MAUVE. *Ber. deut. keram. Ges.*, **8** [4], 209–24 (1927).—A review of the literature reveals two types of elutriation apparatus the Schöne and the Schulze. Other types such as those designed by Schurecht, Bollenbach, and Harkort are modifications of the two former. The following table shows the relation between the grain size (d) and the elutriation velocity (V) obtained by R. and M. when using the Schöne apparatus. (d') is the calculated value obtained from the equation $d' = .495\sqrt{V}$.

V in mm./sec.	(d) measured	(d') calculated
.122	.0185 mm.	.0173
.203	.0217	.0223
.544	.0354	.0365
.994	.0490	.0493
1.549	.0616	.0616
2.060	.070	.071
3.430	.092	.092
6.240	.135	.124

The Schulze apparatus is described by H. Harkort in *Ber. deut. keram. Ges.*, **8** [1], 21 (1927). The relation between the elutriation velocity and the grain size obtained when using the modified Schulze apparatus is as follows:

Diameter of nozzle	Velocity mm./sec.	Grain size mean value
1 mm.	.095	.015 mm.
1.5	.245	.025
2.0	.456	.038
2.5	.692	.050
3.0	1.027	.067
3.5	1.338	.080
4.0	1.692	.103
4.5	2.092	.139
5.0	2.616	.161
5.5	3.196	.206
6.0	3.60	.247

F.P.H.

Elasticity of some minerals and its measurement. A. JOHNNSEN AND T. C. PHEMISTER. *Jour. Geology*, **33**, 268–71 (1925); abstracted *Mineral. Mag.*, **21** [118], 323 (1927). F.P.H.

Representation of a four-component system on a parallelogram. SPINDEL. *Tonind. Ztg.*, **51** [70], 1239–41 (1927). F.P.H.

Study of the three-component system of lime-silica-alumina. JANECKE. *Tonind. Ztg.*, **51**, 1456–57 (1927); *Rock Prod.*, **30** [24], 98–99 (1927).—A reply to a publication

of the results obtained at the U. S. Bureau of Standards by Hansen, Dyckerhoff, Ashton, and Bogue (see *Ceram. Abs.*, **10** [7], 305 (1927)). Previous to that D. had checked the existence of the compound $8CaO \cdot 2SiO_2 \cdot Al_2O_3$ first isolated in 1911 and characterized by monoclinic crystals, optically negative, and having a refraction $\alpha = 1.703$, $\gamma = 1.707$ and double refraction $\gamma - \alpha = 0.004$. The plane of the optical axis is normal to the longitudinal dimension of the crystals; the specific gravity is 3.090. D. now maintains that tricalcium silicate is the prevalent form of crystals mistaken for $8CaO \cdot SiO_2 \cdot Al_2O_3$. The latter compound was found to make up 90% of the fused cement mix, while $3CaO \cdot SiO_2$ could at best make up but 31.3% of the mass. The decomposition of the compound established by J. at low temperature would be easily explained by the conditions of incomplete or metastable equilibrium, carefully outlined in *Zement*, **15**, 610, 643 (1926). It seems unnecessary to assume that the compound $8CaO \cdot 2SiO_2 \cdot Al_2O_3$ is unstable at low temperature. The long needle-shaped crystals, found in a melt containing iron by H., D., A., and B., show great optical resemblance of $3CaO \cdot SiO_2$ to the compound $8CaO \cdot 2SiO_2 \cdot Al_2O_3$. An X-ray study was also carried out under the supervision of J. and resulted in the determination of free lime. It must be assumed that the former did not deal with the regular $8CaO \cdot 2SiO_2 \cdot Al_2O_3$ needles, but with their products of decomposition. Otherwise the X-ray evidence would contradict that obtained by means of the microscope. The only possible correction to J.'s latest publications (*Electrochemie* and *Zement*, 1926) would be that the 8:2:1 compound has a lower stage of existence. This, however, is doubtful as the compound fuses at a very high temperature (1850°C), and would then exist only in a certain range, becoming unstable at lower temperatures. F.P.H.

Silicates of soda in cements. JAMES G. VAIL. *Ceram. Age*, **10** [3], 91, (1927).—Soluble silicates are used as binders in cements for joints between refractory materials, as binding media for acid-resistant structures, and to prevent the penetration of oils, gases, or aqueous liquids. Cements from soluble silicates can be made in great variety to meet a diversity of needs. From a knowledge of the raw materials they can be designed so as to have specified properties. By varying the soda-silica ratio of the silicate, the rate of drying and setting, solubility, viscosity, and a number of other properties can be controlled, including the chemical reactivity at furnace temperatures. The silicates may be introduced as anhydrous powders, hydrated powders, or in solution. V. describes the development of a cement used in fiber board lamination. In many cases the strength can be reduced to get other desirable properties without sacrificing a factor of safety. No silicate solution will lose all its moisture at atmospheric pressure although it may become quite hard. No unchanged silicate of soda is completely insoluble and none containing water is as resistant as the anhydrous substance of the same composition. Admixture of soluble compounds may be used to modify the drying time or elasticity of the silicate. Clay admixtures are used when flow characteristics are important, silica for acid resistance. By a suitable gradation of particle sizes the strength of an acid-resisting cement has been raised from 20 to 1700 lbs. per sq. in. For refractory cements, calcined clays, bauxite, chromite, silica, and asbestos have their place. Partial dehydration increases the strength of cement and another increase takes place when sintering occurs. V. discusses the work of Morey and Bowen on the soda-silica system. A number of different admixtures and coatings are described and the need for more technical testing methods pointed out. A.E.R.W.

Radiation of heat through openings. J. D. KELLER. *Fuels and Fur.*, **5** [12], 1591–98 (1927).—In connection with furnace design it is often required to calculate the amount of heat radiated through openings. The calculation of radiation from completely exposed surfaces is well understood, but the effects of wall thickness in reducing the angle through which direct radiation can take place and increasing the heat transfer

by reradiation from the sides of the opening have not been clearly established. Since radiation from the interior of a furnace is black body radiation, the furnace interior can be regarded as replaced by a flat diaphragm having the same temperature and located at the inner edge of the opening. In the case of a cylindrical opening, K. shows that the ratio between the heat directly radiated from a small area in the center of the diaphragm to that radiated by full radiation through 180° is simply $R = \sin^2(i_1/2)$, where i_1 is the solid included angle. Since mathematical difficulties are encountered in calculating the ratio for radiation from the whole diaphragm approximate methods of averaging and integration were used; *e.g.*, where the included central angle is 90°, and where the diameter of the whole is twice the thickness of the wall. For an element at the center R is then equal to 0.50. The average value for the whole area found by graphical integration is 0.393. The relation between R and the included central angle is shown graphically. Approximate methods show that this relation holds for square openings within 1%, provided the length of the side of the square bears the same ratio to the thickness of the wall as does the diameter of the circle. By making certain assumptions that are usually fulfilled in practice to a reasonable extent, the amount of reradiation from the sides of the opening can be calculated. By averaging and reducing the results in the ratio of area of sides of hole to area of radiating diaphragm, factors were obtained which express reradiation as a fraction of that from a fully exposed surface having various ratios of diameter to thickness of wall. Where the diameter of the opening is equal to twice the thickness, reradiation adds about 65% to the direct radiation. All the calculations are summed up in a curve which can be used very easily in solving problems of this type. The limitations of the method and the discrepancies arising from imperfect black body conditions, polarization, heat conduction at the sides of the opening, and partial attainment of steady-state temperature conditions are discussed. Two examples are worked in detail to illustrate the use of the curve.

A.E.R.W.

Leucite as source of potash. ANON. *Industrial Chemist*, **3**, 512 (1927).—There are 3 commercial processes of extracting K from leucite. (1) Treat with dilute H_2SO_4 at 95°C, allowing the alum to crystallize out; the SiO_2 is converted into sodium silicate with NaOH, and the K salts are treated with HCl for KCl. By this process at Pierre Bénite, near Lyons, 6 tons of alum are made per day. (2) Treat the leucite under pressure with milk of lime; this gives a potash lye which can be filtered and concentrated; the yield is 200 lbs. KOH per T. of leucite. (3) Treat leucite with limestone and iron oxide as flux; potassium aluminate is washed out and filtered from the $CaSiO_3$ and CO_2 is passed through it, precipitating $Al_2(OH)_6$ and leaving K_2CO_3 in solution. By this process 90% of the K_2O and 80% of the Al_2O_3 are extracted from leucite. H.H.S.

Formation of crystalline silicates in aqueous solution under high temperature and pressure. W. IPATIEFF AND B. MOUROMTSEFF. *Nature*, **120**, 713 (1927). Meeting Fr. Acad. Sci., Oct. 3, 1927.—Silica gel after heating for 30–40 hours at 310–320°C under a hydrogen pressure of 200 atmospheres gives hexagonal prisms and pyramids of SiO_2. If H be replaced by CO_2, a crystalline hydrate, $5SiO_2 \cdot 2H_2O$ is obtained. The preparation of crystalline silicates of Mg, Ca, Mn, and Zn is described.

H.H.S.

X-rays and the crystalline structure of materials. WM. H. BRAGG. *Engineer*, **144** [3748], 534 (1927).—The properties of any material depend upon its fine structure. The ultrafine structure is of highest importance, should be recognized and known, and is the real foundation of the properties of the body. In using the X-rays we take advantage of a certain strong tendency in nature for regularity of arrangement. All substances which the engineer handles, as wood and stone, bricks and cement, conductors and insulators, lubricating oils, cotton, wool, and other textile fibers and minerals

have structures on which their properties depend. The fundamental principles of the X-ray method of examining the structures of nature are sketched. The author claims that great power is given us by this method but admits the present inexperience in handling this new power, the lack of understanding all that experiments show, and the deficiencies in our technique, but asserts that the foundation of this new science will be strengthened and broadened and that the superstructure will quickly rise. G.W.W.

The fusibility of the mixtures of lithium and magnesium fluorides. V. P. Il'inskii and P. F. Antipin. *Ann. inst. anal. phys. chim.*, **3**, 464 (1926).—The eutectic lies at 718°, solid solutions being formed on the LiF side. (*C. A.*)

The analysis of fluorspar. Brauer and Ruthsatz. *Chem. Ztg.*, **51**, 618–19 (1927). —Drawe recommended a method which is essentially that used by B. and R. for some years and depends upon the indirect determination of the F combined with Ca. The method is good but if $BaSO_4$ is present, as frequently happens, boiling with Na_2CO_3 will lead to the erroneous conception that all of the SO_4 comes from $CaSO_4$. Also in the residue, the Ca cannot be determined in such a case without prior removal of Ba. The direct determination of F by treatment with SiO_2 and H_2SO_4 with volatilization as H_2SiF_6, although not altogether accurate, is better than not to determine F at all. (*C. A.*)

The application to iron and neodymium oxides of a general method for the synthesis of silicates. A. Duboin. *Compt. rend.*, **185**, 416–17 (1927).—SiO_2 and Nd_2O_3 are added to KF or KHF_2, previously melted in a Pt crucible. After cooling the mass is fused with KCl and then extracted with H_2O. By fractional crystallization a fine, crystalline product is obtained corresponding to the formula: $Nd_2O_3 \cdot 3K_2O \cdot 9SiO_2$. The method is applicable to Fe but it is more difficult to fractionate the product. (*C. A.*)

Surface tension balance. E. L. Warren. *Phil. Mag.*, **4** [7], 358–86 (1927).—The method used is a modification of Jaeger's method, and has been designed primarily for the experimental determination of the temperature coefficient of surface tension, and for the investigation of the dependence of the surface tension of solutions on their concentration. The chief feature of the method is that it enables all such measurements to be expressed in terms of the surface tension of some appropriate standard liquid such as water. The apparatus consists of 2 small circular jets of the same cross-section, which are in gaseous connection with each other. The jets are immersed separately in the liquids to be measured. The air in the bottle supplying the gas pressure is maintained at a pressure of a few mm. of Hg above that of the atmosphere. A pinch-cock is opened until bubbles of gas escape at intervals of about 5 sec. from one of the jets. The depth of immersion of one of the jets is adjusted until the bubbles escape approximately alternately from the 2 jets. This arrangement enables the surface tension of the liquid in the one beaker to be balanced against that of the liquid in the second beaker. The balance is independent of the pressure maintaining the bubble system. In order that this may be so it is essential that the 2 jets should be identical in size and shape. The surface tension of H_2O is determined as a function of temperature and of NaCl as a function of concentration. (*C. A.*)

Physical behavior of kaolins between 500° and 1100°. O. Pahnke. *Phys. Ber.*, **7**, 1110 (1926). (*T.E.C.S.*)

Physical behavior of kaolins and ceramic bodies between 800° and 1300°. A. Kanz. *Phys. Ber.*, **7**, 1111 (1926). (*T.E.C.S.*)

The connection between heat of fusion and specific heat. Karl Lichtenecker. *Physik Z.*, **28**, 473–75 (1927).—The fact that the heat of fusion of ice corrected for the work done is close to the heat content of the ice itself, is discussed in relation to the degrees of freedom of the molecules and the rigidity of the ice crystal. (*C. A.*)

A valence-name-formula-solubility chart. G. N. QUAM. *Proc. Iowa Acad. Sci.*, **33,** 170 (1926).—The chart includes the names and symbols of all the common radicals used in general chemistry courses arranged in a definite order according to valence. Each small rectangular space formed by horizontal and vertical lines including a positive and negative radical represents a compound and contains a symbol representing the solubility in g. per 100 g. of H_2O at 18°. Each large rectangular space represents compounds having a common type formula. The primary purpose of the chart is to aid the student in acquiring speedily a working knowledge of valence, radicals, and formula writing. (*C. A.*)

The stability of suspensions. II. The rate of sedimentation of kaolin suspensions containing colloidal silicic acid. W. O. KERMACK AND W. T. H. WILLIAMSON. *Proc. Roy. Soc. Edinburgh*, **47,** 202–21 (1927).—The previous work on sedimentation in the absence of silicic acid was repeated and extended to include the effect of all alkali metals except Rb. In acid suspensions the action in inhibiting sedimentation is least in the case of Cs and greatest in the case of Na. This is in accord with the Gedroiz-Wiegener theory of base exchange in soils and stability of clay suspensions. The theory is that the p.d. of the Helmholz double-layer is proportional to the effective distance between the layers. The highly hydrated ions such as Na are unable to approach very near the surface of the clay; they form stable suspensions. The order of stabilizing influence on clay is $Cs < Rb < K < NH_4 < Na < Li$. The ions which approach most closely to the clay and stabilize least are most difficult to displace from the clay. Normally a small concentration of silicic acid protects colloidal clay slightly. Under some conditions the effect of the silicic acid is to produce the precipitation of a film of insoluble material on the surface of the particles of clay. Such films cause abnormally rapid sedimentation. Under other conditions the silicic acids prevent precipitation. In addition to the data on alkalis, data are given on sedimentation in the presence of silicic acid by $CaCl_2$, $CaSO_4$, $CaH_4(PO_4)_2$, $AlCl_3$, $FeCl_3$, and $LaCl_3$ in the presence of HCl; and $CaH_4(PO_4)_2$ in the presence of H_3PO_4 and a mixture of $CaSO_4$ and $CaH_4(PO_4)_2$ in the presence of HCl. Seventeen figures are given, graphically depicting the behavior of the clay under varying concentrations of these salts and of the H-ion for each concentration of salt. (*C. A.*)

The constitution of kaolin. M. DOMINIKIEWICZ. *Roczniki Chemji*, **5,** 252 (1925). (*T.E.C.S.*)

Heat conduction of solids. GEO. G. BROWN AND C. C. FURNAS. *Trans. Amer. Inst. Chem. Eng.*, **18,** 295–307 (1926).—New differential equations representing the laws of heat conduction are derived without making the simplifying assumptions that the thermal conductivity and specific heat are constant. These equations are solved by graphical methods and applied to the determination of thermal conductivities, specific heats and heats of transition or reaction. A solid cylinder with a center axis consisting of a heating element giving even distribution of heat throughout its length is employed. A bibliography is included. For Part I see *Ceram. Abs.*, **7** [1], 53 (1928). (*C. A.*)

Sillimanite inversion. F. RAAZ. *Tscherm. Miner. u. Petrogr. Mitt.*, **38,** 583 (1926). —Changes in volume on heating sillimanite are observed and the specific gravity of the fired material is determined. No change or modification is observed up to about 1400°. Between 1600° and 1700° the density falls from 3.247 to 2.950. At this temperature the material changes to a mass resembling porcelain, mullite and glass being formed. These observations are contrary to Peck's results, who found an increase in density when andalusite changed to mullite and glass. (*T.E.C.S.*)

Titanium sesquioxide. GULBRAND LUNDE. *Z. anorg. allgem. Chem.*, **164,** 341–44 (1927).—TiO_2 heated in a stream of H_2 for 20 minutes at 1000° lost 4.64% in wei[illegible]

whereas the transition $TiO_2 \rightarrow Ti_2O_3$ requires 10%. According to the method of Friedel and Guerin, a mixture of H_2 and $TiCl_4$ is passed over TiO_2 at about 650°. An amorphous blue-black product and, in very small quantities, a red-violet sublimate were obtained. The temperature was then raised to 1000° and the product heated in the $TiCl_4$ stream for 30 minutes. X-ray investigation indicates that the product obtained is identical with that of Friedel and Guerin. Axial ratio = 1.320, d = 4.605 (Friedel and Guerin: $c/a = 1.316$; d = 4.601). (*C. A.*)

The reduction of alumina and other oxides by tungsten at high temperatures. H. v. WARTENBERG AND H. MOEHL. *Z. physik. Chem.*, **128,** 439–44 (1927).—A small rod of Al_2O_3 heated in a W-wire furnace failed to melt at 2100° (melting point 2050°) but reacted to form a crust of fine black crystals on the rod, the heating filament decreasing in diameter and WO_2 depositing on the sides of the furnace. It was shown that this reaction could not be explained by the presence of O_2 in the N_2 atmosphere. The phenomenon is explained by the vaporization of Al_2O_3, a reaction between the gaseous Al_2O_3 and the W-filament to form Al and WO_2 and the migration of the WO_2 and the gaseous Al to the Al_2O_3 rod, where on account of a lower temperature the reaction at the filament reversed and W and Al_2O_3 formed. Similar results were obtained with MgO, ZrO_2, and ThO_2, at somewhat different temperatures. These reactions are correlated with the Nernst approximation formula and found to be in agreement. The results are interpreted to be in confirmation of the former conclusion that ThO_2 in W-lamps must be effective as Th, though within the W-filaments ThO_2 can be found because of the retention of the WO_2 vapor. (*C. A.*)

Plasticity of clays. A. v. BARANOFF. *Zeit. f. techn. Physik.*, **7,** 76, 191 (1926). (*T.E.C.S.*)

BOOKS

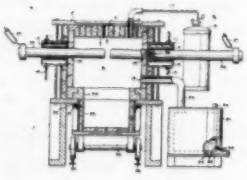
Frequency Curves and Correlation. W. P. ELDERTON. 2nd ed., London: C. and E. Layton, 1927. Price 15*s*. A comparison of various systems of curves is presented. Other chapters have been enlarged and rewritten, and one on practical correlation has been added. H.H.S.

Principles of Chemical Engineering. W. H. WALKER, W. K. LEWIS, AND W. H. MCADAMS. 2nd ed., 625 pp.; illustrated. New York: McGraw-Hill Book Co., 1927. Price $5.50 postpaid. H.H.S.

PATENTS

Manufacture of titanic oxide. NORBERT SPECHT. U. S. 1,649,496, November 15, 1927. In the manufacture of well covering titanic oxide, the process of hydrolizing at temperatures from 160 to 180°C by means of solutions having a specific gravity ranging from 1.35 to 1.55.

Production of magnesium from magnesia compounds. WILLIAM KOEHLER. U. S. 1,650,893, November 29, 1927. The process of reducing a magnesium compound to metallic magnesium which comprises intensely heating the magnesium compound to a reacting temperature in a current of hydrogen gas heated to the same temperature, and reducing the intensely heated magnesium compound to metallic magnesium by the hydrogen, conducting the vapors of the reduced metallic magnesium by the current of excess hydrogen out of the furnace, and condensing the metal in the presence of the hydrogen.



Production of magnesium from dolomite. WILLIAM KOEHLER. U. S. 1,650,894, November 29, 1927. The process of obtaining metallic magnesium and calcium carbide from a charge which contains magnesium and calcium compounds, which comprises heating the charge in the presence of carbonaceous matter in an electric furnace in a current of a reducing atmosphere until reacting conditions are obtained, forming calcium carbide and metallic magnesium, and removing the latter from the furnace.

Base-exchanging silicates. P. N. ENGEL. Brit. 277,082, November 2, 1927. Base-exchanging silicates are produced by reacting on alkali-metal silicate, a nonakaline solution of an amphoteric metal salt, and an acid in such proportion that a product is produced containing one molecule of alkali metal oxide, one molecule of amphoteric metal oxide, and 10 or more molecules of silica, the reaction being effected so as to form a gel embracing the entire volume of the solution. The examples describe the production of gels from sodium silicate, aluminium sulphate, and sulphuric acid, but aluminium acetate or a salt of another amphoteric metal may be used, and potassium silicate may replace sodium silicate. The reaction mixture may be somewhat alkaline or neutral, but should not contain excess of acid. The gel is dried below 100°C, preferably at about 80°C, and subsequently washed to remove soluble salts and break up the material. Small pieces may be formed by heating the mass to 100°C, and then treating with cold water. Larger pieces may be obtained by treating the dried product with steam.

Treatment of lithium-containing silicates by means of neutral alkali salts. METALLBANK U. METALLURGISCHE GES. A.-G. Brit. 269,878, March 31, 1927. Water-soluble lithium compounds are obtained from silicates containing lithium with the use of less alkali salt than heretofore if definite temperature limits of 700–950° are maintained in a mechanical roasting furnace, rotary drum furnace, or Dwight-Lloyd furnace.

(*C. A.*)

General

Powdered coal for small boilers. HENRY KREISINGER. *Blast Fur. Steel Plant*, **15** [12], 591–94 (1927).—The good results that are being obtained with powdered coal in large central stations have created an interest in powdered coal among the operators of small steam plants and small boiler units of industrial establishments. The small plants are usually stoker- or hand-fired, often with unsatisfactory results; the monthly operating efficiency seldom reached as high as 70%. Although the small plants can be benefited by the installation of powdered-coal firing, they cannot as a rule obtain the high efficiency obtained by the large central stations. Limitations in the design and operation of these plants make high efficiencies impractical. These limitations are pointed out and examples are given of the application of pulverized coal in industrial plants, some with very small units. The efficiencies obtained with some of these installations on large units are high, averaging 88 to 90% a month chiefly because with the large units the designing engineer used such combinations of apparatus as could be operated with high efficiency. Large economizers or a combination of a smaller economizer and air heater were used for good heat absorption and for good combustion large, well-proportioned furnaces with water-cooled walls were designed. It is possible thus to burn the coal with low excess air, easy ash removal while the furnace is in operation, and small furnace maintenance. Although there is very little or no coal burned during banking periods, there are losses from radiation and from heat being carried up the stack by the unavoidable flow of air through the setting. The setting is cooled and when the unit is started heat is put into the setting during the time it is heated to operating temperatures. In the effort to keep the first cost down the furnaces of the small plant must forego the advantages that can be derived from air- or water-cooled walls and bottoms. The furnaces may have to be built with solid brick walls and flat bottoms, which construction makes it necessary that they be operated with high excess air to avoid erosion of the walls and to make ash removal possible without shutting down the boiler. Such operation lowers the efficiency. Diagrams are presented and operating data collected from various installations are presented.

F.P.H.

Résumé of Bureau of Standards investigations. ANON. *Ceram. Ind.*, **9** [6], 667–68 (1927).—Progress reports on the following investigations are given: (1) Feldspar

and its effect in pottery bodies; (2) resistance of ceramic glazes to abrasion; (3) effect of calcined cyanite in porcelain bodies; (4) microstructure of earthen ware; (5) composition and physical properties of glass; (6) problems relating to sagger clays; (7) physico-chemical factors affecting the consistency of enamel slips; (8) effect of typical enamels on colors obtained with various stains; (9) effect of composition on the properties of ground coat enamels; (10) cast iron for enameling purposes; (11) physical properties of clay bodies as affected by drying; (12) study of glazes; (13) investigation of English and American china clays. F.P.H.

American Refractories Institute Meeting in St. Louis. ANON. *Ceram. Ind.*, **9** [6], 682 (1927).—The program of the meeting of the American Refractories Institute in St. Louis December 6–7, and titles and authors of the papers presented are given. F.P.H.

Container men order "full steam ahead." ANON. *Ceram. Ind.*, **9** [6], 684–88 (1927).—A report of the meeting of the Glass Container Association in Pittsburgh, October 27–28. F.P.H.

Ceramic men will support National Ceramic Council. ANON. *Ceram. Ind.*, **9** [6], 688 (1927). F.P.H.

Ohio Ceramic Industries Association studies administrative problems. ANON. *Ceram. Ind.*, **9** [6], 688–90 (1927).—A report is given of the fall meeting of the Ohio Industries Association held at Columbus, November 18–19. The feature of the meeting was the report by G. A. Bole on the recent survey made of the ceramic industry of Ohio. The results will be interesting to every branch of the ceramic industry in Ohio, with special reference to cost of manufacture. F.P.H.

English ceramic manufacturers ask that imported ware be stamped with mark of origin. ANON. *Ceram. Ind.*, **9** [6], 690 (1927).

Manufacture of whiting in England. H. S. SPENCE. *Rock Prod.*, **30** [23], 52 (1927).—A flowsheet illustrating the manufacture of English whiting is presented. The mining of the chalk is described. F.P.H.

Precarbonization of power plant coal. CRAWFORD. *Combustion*, **17** [2], 94 (1927).—Low temperature carbonization is seen as the next forward step in the use of coal. The various processes are discussed, also some of the economic problems involved. The writer believes that the indirect heated low temperature carbonization is preferred for 5 reasons as follows: (1) low temperature coke has greater "reactivity"; (2) low temperature gas has a calorific value nearly twice that of high temperature gas; (3) three times as much tar obtained by this method as by high temperature method; (4) the initial costs, fixed charges, labor, and maintenance costs are lower; (5) less fuel consumed for carbonization and less heat loss in the condensing system. The difficulties involved are purely mechanical ones, and a simple mechanical method is needed. G.W.W.

Recent operating figures. ANON. *Combustion*, **17** [2], 93 (1927).—Report of yields obtained from the Maclaurin smokeless fuel plant at Dalmarnock Gas Works of the Glasgow Corp. Quantities produced per ton of coal carbonized are: oil, 20.38 gals.; sulphate of ammonia 31.94 lbs.; gas 33,849 cu. ft. Calorific value of gas 239.5 B.t.u.; gas therms 80.96, solid fuel 9.9 cwts. G.W.W.

The Institute of Fuel. I. *The Engineer*, **144** [3750], 594 (1927).—A. Mond in his presidential address before the Institute of Fuel relates some of the problems of the Institute and calls attention to the manner in which the economic development of a nation is bound up with scientific development in fuel-producing and using industries. The whole history of the world shows that civilization has advanced in stages just as invention has developed. Only by the provision of cheaper fuel, better utilization of fuel, cheaper power, and cheaper products generally, will it be possible for a nation as a whole to increase its spending power, and in turn improve the prospects for the industries of the country generally. G.W.W.

Glass Container Association meeting at Pittsburgh. ANON. *Ceram. Age*, **10** [5], 178–79 (1927).—A staff report of the meeting of the Glass Container Association in Pittsburgh, Oct. 27–28, 1927. A.E.R.W.

Chemists in ceramic industries. FELIX SINGER. *Keram. Rund.*, **35**, 19–20 (1927). —A plea for more extensive training of chemists for employment in ceramic industries. H.I.

National Ceramic Council organized for research. ANON. *Brick Clay Rec.*, **71** [8], 566 (1927); see *Ceram. Abs.*, **6** [12], 625 (1927). E.J.V.

Ohio Ceramic Industries Assn. Fall Meeting. ANON. *Bull. Amer. Ceram. Soc.*, **6** [12], 378 (1927); *Clay-Worker*, **88** [5], 364 (1927).—A brief report of the meeting giving an outline program of papers presented. E.J.V.

Ceramic short course, O. S. U. ANON. *Bull. Amer. Ceram. Soc.*, **6** [12], 376–77 (1927); *Clay-Worker*, **88** [5], 364 (1927).—A list of papers given by various lecturers in the short course in ceramics held at Ohio State University, November 14–19, 1927. Registration list is also given. E.J.V.

Efficient clay plant operation. S. A. PHILLIPS. *Brick Clay Rec.*, **71** [8], 550–55 (1927).—A discussion of management in industry. Development of the profit idea, production problems, qualities of a manager, and the impartial scrutiny of ideas are taken up. Problems encountered in searching for the "one best way" are listed. These include the factors which control the speed and output of a given process or machine, the reason why the actual output is less than the calculated output, and why some workers produce more than others. Various intricate problems of management are enumerated. Two elements of every task, according to the "functional" system of Taylor, are (1) the planning and (2) the performance of the work. The "best way" for each operation should be established and workmen selected for these operations according to their fitness therefor. The administration systems of Taylor and Emerson are explained. The need for mass consumption in order to have mass production and the dependence of selling on manufacturing is pointed out. E.J.V.

Business outlook for 1928. GEORGE E. MACILWAIN. *Brick Clay Rec.*, **71** [8], 556 (1927).—An economical review of business conditions and the possibilities for 1928. E.J.V.

American Face Brick Assn. studies problems of face brick industry. ANON. *Brick Clay Rec.*, **71** [10], 700–701 (1927).—An advance discussion of the Meeting held at Hot Springs, Va., November 30–December 2, 1927. Production and distribution are studied. E.J.V.

Lower cost production in brick manufacturing. S. A. PHILLIPS. *Brick Clay Rec.*, **71** [10], 704–709 (1927).—Continuity, system, speed, economy, power, and accuracy are the principles which must be adopted by every manufacturing enterprise which aims at the production, in large quantities and at a low cost, of a useful commodity of uniform quality. A planning department should be established for (1) planning the orderly progression of the product through the plant, thus giving effect to the principles of continuity and system, (2) delivering the work to the workman instead of letting the workman find the work, thus promoting the speed and accuracy of operations, and (3) breaking each operation up into its constituent elements so as to make possible the most effective utilization of power and the attainment of maximum accuracy. Methods used in brick manufacturing are discussed and the applicability of these principles to brickmaking processes is pointed out. E.J.V.

Merseyside industries. A. HOLT. *Chem. and Ind.*, **46T**, 439–44 (1927).—Merseyside is the geographical area 15 miles round Liverpool. Vessels came from Cornwall with china clay en route by canal to the potteries, and the Lancashire coal field was opened for export by these and similarly returning vessels. Glass and pottery works

were established in the Merseyside 3 centuries ago. In Liverpool itself, there were potteries from 1643 to 1841. In Paradise Street, Liverpool, Priestley stayed, and here Wedgwood and Bentley arranged their partnership, as a result of which Wedgwood ware was for a time conveyed unfinished from the potteries to Liverpool, there to receive the well-known blue coloring. Pottery was also made at Rainford, Bickerstaffe, Eccleston, Sutton, Whiston, Prescot, and St. Helens. The glass industry was established in Liverpool in 1715, in Prescot in 1751, and in St. Helens in 1773. Crown glass was started in 1827 by Pilkington's of St. Helens, makers of the first English sheet glass. H.H.S.

Empire Mining Congress in Canada. ANON. *Chem. and Ind.*, **46**, 1012–13, 1034–35, 1078–79 (1927).—A series of articles descriptive of the industrial development of Canada. H.H.S.

The care of the eyes in industry. T. LEWIS. *Chem. and Ind.*, **46**, 1086 (1927).—The subject is treated under 3 heads (1) hygiene, (2) accidents and preventive measures, (3) standards of vision and their effect on the efficiency of the worker. The best type of light is one which approaches the yellow of the spectrum; indirect lighting is better than direct. A minimum of 3 candle feet of light in the plane of work, and of 5 candle feet for fine work, is suggested. A standard of vision is necessary in industry; many workers use only one eye, with consequent inability to appreciate depth of focus; others are color blind. Approximately 7.5% of all blind persons in England owe the defect to industrial accidents. H.H.S.

Waste-heat boiler plants attached to circular ceramic furnaces. E. FROMME. *Arch. Wärmewirt*, **8**, 279–82 (1927).—The installation illustrated and described recovered 53% of the heat in the fuel used. (*C. A.*)

Effect of water on the workability of clays. H. SALMANG AND A. BECKER. *Sprechsaal*, **59**, 389 (1926).—The action of a disperse medium depends first on its chemical nature (content of H- and OH-groups), and only in the second place on its viscosity. The favorable effect of water is explained by the fact that it contains both these groups. This applies particularly to clay-water systems. The effect of viscosity is more marked with finely divided steatite and mica, and is most pronounced in the case of graphite, with which viscous fluids must be used. (*T.E.C.S.*)

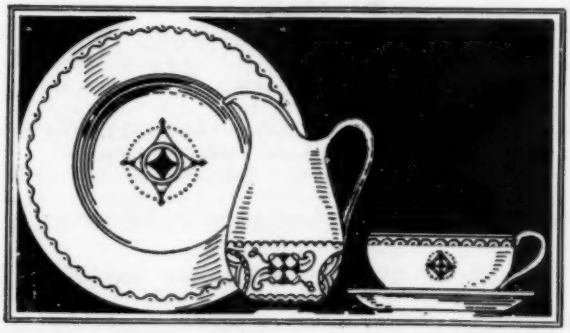
BOOKS

Index to Proceedings, A.S.T.M., 1921–1925. Philadelphia 1927, pp. 244, $2.50. F.P.H.

Boiler Feed Water Purification. SHEPPARD T. POWELL. New York: McGraw-Hill Book Co., 1927, 363 pp., $4.00. F.P.H.

Book Review

A.S.T.M. Standards. Philadelphia, 1927. Contains the 340 Standards adopted by the A.S.T.M. and is issued in 2 parts. Pt. I, Metals, 878 pp.: 63 standards relating to steel, 9 wrought iron, 9 pig and cast iron, 8 ferro alloys, 50 nonferrous metals, 8 miscellaneous subjects. Price, cloth $7.50; half leather, $9.00. Pt. II, Nonmetals, 1006 pp.: 43 standards relating to cement, lime, gypsum, and clay products; 31 preservative coatings; 16 petroleum products and lubricants; 33 road materials; 25 waterproofing and roofing materials; 25 rubber products, insulating and textile materials; 23 coal,coke, timber, and miscellaneous materials. Price, cloth $7.50; half leather $9.00. Both parts, cloth $14; half leather $17.



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Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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Vol. 7 February, 1928 No. 2

EDITORIAL

MANAGEMENT OR TECHNICAL KNOWLEDGE— WHICH IS MORE IMPORTANT?

There is no doubting the importance of the knowledge of scientific facts and their relation to production problems. If one is to compete in the most critical market, the market of narrowest profit margin, one must not only know how to produce the best ware at the lowest cost, but also how to keep in touch with the ever increasing fund of fundamental and applied information. He must know how to apply this information to his manufacturing problems.

There is no question of the equally important ability of translating technical knowledge of ware production into product movement and distribution.

To succeed in a close critical market a firm must have a product equal to any, production cost must be low, and the firm must be alert to any change which will affect either the quality or the cost of the ware. The firm must be equally alert to changes in the market conditions, market needs, and business management.

Inferior products at relatively high factory costs have held their own on account of the skill of the general managers in financing and distributing the products. Conversely, a good product made at relatively low cost has often found no market and the company has failed because of mismanagement.

Conditions are changing rapidly. What has been true regarding the relative importance of production and management skill is not true now; they are of equal importance.

Firms making the same or equivalent ware may have equal skill in development and production, and yet not alter their relative abilities to market their products or even to interpret the market requirements.

If china ware, terra cotta, or enameled ware producers would freely exchange their information on production methods, equipment, and materials, there would still be that same difference between them in business development and business getting.

Since one manufacturer's poor product will discredit with the consumer all manufacturers of a like product, and since competition in all lines is now as much or more a competition with products of other materials, and since in spite of the strictest surveillance, knowledge is quickly acquired by competitors, it would be to the advantage of each manufacturer to exchange freely all manufacturing information and to depend on the personnel of the management and sales representatives for trade advantages.

Trade advantages are not obtained in these days by closed doors, "secret" processes, etc., in manufacturing. Trade handicap, on the other hand, is caused by inferior ware, no matter by whom it is produced, and by price cutting below what it will cost to produce a legitimate quality of ware.

Competitors' shortcomings in quality of ware and in cost of production certainly offset much of the advantage of greater skill in financing, distributing, and in human engineering within the plant.

PAPERS AND DISCUSSIONS

SCIENCE VERSUS ENGINEERING IN THE SCHOOLS—A FURTHER CONTRIBUTION TO THE SYMPOSIUM ON CERAMIC EDUCATION[1]

By A. F. Gorton

ABSTRACT

In discussing ceramic education it is suggested that (1) as it is the function of a technical school to impart as complete a scientific foundation as possible to its graduates, the tendency is to produce technologists rather than engineers; (2) engineering ability does not develop from formal training but from individual traits or inborn qualities; (3) the average-size plant should endeavor to make better use of the talents and ability of their so-called practical men by encouraging them to acquire technical knowledge through evening courses and extension work. The benefits of coöperative agreements with local educational institutions by maintaining scholarships are also pointed out.

Introduction

In reading the recent discussions on the aims of present day ceramic education, which have appeared from time to time as articles and editorials in the *Journal*,[2] one cannot fail to realize how deeply they strike at the foundation of all technical or engineering training in this country. To one who has spent the last ten years in the ceramic industries and is now striving to train undergraduates for business, technical or, perhaps, engineering careers, the heartfelt comments and criticisms of men prominent in the schools and ceramic industries come with almost a poignant force. Certainly there is, important above all else, a need for further advice from the manufacturers, the leaders in the various industries, and it is the hope of the writer that these remarks may stimulate expressions of opinion by others like Mr. Green,[2] who by their commercial activities make possible the continued functioning of the technical schools.

Ceramics a Broad Subject

Undoubtedly many recall the informal symposium initiated by R. C. Purdy at the Philadelphia Meeting (1920). Though the burden of the discussion centered around the leadership in the ceramic world of men of nonceramic training, the various remarks very clearly brought out the tremendous breadth of ceramics and the impossibility of giving instruction in the intricacies of the various technical subdivisions of the parent science. This complexity, however, now characterizes electricity and chemistry, to mention only two of the subjects much in

[1] Received December 5, 1927.

[2] "Symposium on Ceramic Education under Auspices of the Educational Committee," *Bull. Amer. Ceram. Soc.*, **6** [11], 342 (1927), (with references to various editorials). "Discussions on Ceramic Education" (with specific reference to the needs of the refractories industry), *Bull. Amer. Ceram. Soc.*, **6** [8], 238 (1927).

the public eye during the last thirty years; and, though we all admit that these two fields have been overcrowded with students in the last twenty years (just as was the field of law in an earlier period) still it is clear to the experienced observer that new developments such as radio, automotive metallurgy, artificial silk, new food products, fabrics, dyes, antiseptics, germicides, etc., constantly offer a wealth of opportunity to the young graduate with at least some breadth of vision. This wealth of opportunity, however, which characterizes ceramics as well as the other subjects would only confuse the college sophomore who is involved in studies of a fundamental character. Even seniors have a certain short-sightedness which prevents them from looking ahead, and few indeed have any clear-cut idea of the job best suited to their mental equipment, personality, and individual leanings.

The Scientist and Engineer in Industry

While the remarks of R. C. Purdy, H. F. Staley, and others, make clear the necessity of employing men of different talents and attainments in a factory of even moderate size and distinguish rather sharply between the functions of the engineer and the technologist in the large plant, there is on examination a certain vagueness or confusion as to the training which should be given to the two types of workers. This confusion is apparent in the remarks of the plant executives as well as professors of ceramic engineering. It is not difficult to see that on the one hand the schools must confine themselves largely to instruction in codified knowledge or science rather than in the solution of everyday problems, and that on the other hand a man's progress after the first five years depends mostly on individual traits and not on acquired knowledge. The writer is in agreement with the thoughts of Mr. Staley and those of A. S. Watts on the ultimate financial success of a given group of men, including noncollege men as well as college graduates. That breadth of vision which Mr. Staley says is a requisite in the high-salaried executive is a quality not necessarily acquired in college, and as we all know the majority of managers and superintendents even in the industries commonly regarded as technical, not to mention the ordinary, everyday establishments, have had little beyond a public school education. Some of the confusion referred to above is due to the fact that many plants cannot afford to hire both types of men, nor would there be, in general, sufficient work of both kinds to keep more than one man busy. The college instructors are aware of this situation and as A. F. Greaves-Walker remarks, they seek to recommend a youth who has sufficient scientific knowledge to cope with the immediate technical demands of the job and who they hope will develop into a real engineer. Experience has shown that perhaps a majority

of graduates are not capable of this development, but in the opinion of the writer this is certainly not a valid reason for deserting technology in the schools. As will be shown later there is a method of meeting this difficulty which has not been mentioned in previous discussions of the SOCIETY, but which is of growing importance, as shown by the present trend in certain phases of the work of the high schools in the larger cities.

Duty of Technical Schools

In the brief time at their disposal, usually not more than four years, what are the technical schools to teach? It is clear that the bulk of the time must be devoted to instruction in codified knowledge or science which is nothing more than the logical classification of facts brought out by past experience. Even in the applied sciences facts must be collected, analyzed, and classified before being taught. While instructors constantly assign "problems" to the students there is a vast difference between such problems and those which arise from day to day in the practical operation of any plant. In brief, the first class of problems are "textbook" problems, *i.e.*, capable of solution by applying certain formulas found in the book, rather than by demanding the exercise of judgment or common sense. Necessarily, this judgment involves considerations of economy, expediency, efficiency, etc., as well as technical correctness, and therefore is something not usually learned in college courses. If this be true, it follows that no school can deliberately train a man to be a successful engineer, but every school can do its best to impart that solid groundwork which every real engineer should have at the beginning of his career. There is a divergence of opinion as to what courses constitute a good foundation, some schools insisting on considerable training in the languages, arts, and literature in addition to science; and the trend seems to be toward a stiffening of the requirements in these subjects rather than toward a letting down of the bars, and this attitude seems to be reinforced by the opinions of the industrial executives.

Specialized or Graduate Work

It is the consensus of opinion among engineers as well as professors that four years is a rather brief time in which to lay this solid foundation. In medicine, law, and the pure sciences it is admitted that it takes at least six or seven years to train a specialist. In these subjects, therefore, a six-year combination course is in vogue, or the total time is divided up into a collegiate course of three or four years followed by a graduate course of three to four years. In the writer's opinion, the latter method is applicable to ceramics as well as to other applied sciences, but not in the sense that such a course would be necessary to develop the average type of engineer. In fact, since such graduate work would be capped by the doctor's degree,

there would be a distinct tendency to develop technologists rather than engineers. This has been well demonstrated by the type of work done in ceramics up to the present time by men who have taken the doctor of philosophy degree in science. Such work as that of the Geophysical Laboratory is immensely valuable to the ceramic industry and more investigators of this type are needed; but it is equally true that engineering ability is not necessarily developed by graduate work and in fact there is a distinct feeling on the part of the plant men that such training is not required for their purposes. Here again the difference between the large plant and the average factory must be recognized, but the point of view throughout this article is that of the latter. Therefore, nothing would seem to be gained by extending an engineering course beyond the customary four years.

Night Schools and Extension Courses

Although it is a common thing to find sophomores and juniors who have not decided in which direction their careers are to lie, the instructor is apt to be shocked by the discovery that many of his seniors are utterly at a loss to know what kind of work they should take up and this indecision extends in some cases to the day of graduation and beyond. That this condition is found in technical schools as well as in arts colleges seems surprising but is nevertheless true, as evidenced by statistics showing the occupations of recent technical graduates. The fact that so many engineering graduates sell bonds or real estate the first year or two is not amusing, in many cases it is tragic, although to be sure many executives contend that such experience is valuable to the future engineer. At the very least it is a commentary on the efficiency of the schools, since many such graduates should have been discouraged from going into engineering or should have been diverted into other fields of activity. The colleges by no means bear all the blame, however, as the general public is beginning to see, for much of the trouble arises from the failure of the secondary and grade schools to impart a thorough foundation for college work. Here, again, opinions differ, and perhaps in the future the difficulty will be solved by a further classification of our public schools, somewhat along the lines in vogue at the present time in Germany. Since, generally speaking, economic necessity compels most young men to be content with the average college training (or less), it is inevitable that many should find themselves after graduation in jobs for which their training is inadequate. Even so, there is no cause for discouragement, for in addition to the splendid courses available in the evening classes of the high schools in most cities, the colleges and universities offer similar courses after business hours or at least extension courses, and certain large industrial concerns go much further in this direction with their own employees, some even

offering graduate work in the sciences, somewhat as the Bureau of Standards is doing.

The question of adult (and parent) education is engaging the attention of the public but much greater stress will be placed on it in the future. People are beginning to realize that it is wrong to encourage the graduate in the notion that he is "educated," or as one writer expresses it, "that he may close his eyes and seal up his brain against further infiltration of knowledge." The work that is being done in East Liverpool in the evening school for pottery workers is typical of the continuation schooling, which should be more widely available throughout the country. There is in nearly every factory an earnest desire on the part of many workers for further technical knowledge, and under present conditions it is very difficult to satisfy this craving, owing to the inability of the colleges to go beyond the limits of their ordinary, daytime instruction. If the colleges only realized it, there is a vast field open to them in this direction which the ordinary correspondence schools have not touched, and this field would provide instructors with students of the type with which every professor longs to deal, students who are in earnest, who have a definite goal before them, and are driving toward that goal.

The Employers' Need; How It May Be Met

A certain successful manufacturer of dinner ware recently expressed his need of a technical man to do certain work in his plant. Although admitting that he could secure from the colleges a young graduate capable of carrying on certain research work on the kilns, he hesitated to engage such a man on the plea that he would not be likely to develop into a pottery engineer. In common with many executives in his own as well as other industries, this man had developed an attitude against technical men and technical work in his own plant which is the result, not so much of financial limitations or scarcity of real problems pressing for solution, as of the feeling that the employee might not adapt himself to the situation, in other words, develop into a real engineer. It is a fact that, under stress of wartime need, certain employers engaged technical help which they later felt they could not afford, the employees in these cases being discharged. In other cases the beginnings of a research department were set up, but perhaps full advantage was not taken of the talent at hand, because the management reserved the real problems for the practical man in the plant. In any event, the war period did wonderful service by opening the eyes of plant managers to the benefits possible from technical and research work carried out in their own establishments. The solution seems, in many cases, to lie not so much in attempting to hire the ideal man for the job as in

adapting the help already available to the particular need, in addition to an intelligent utilization of the research work constantly being turned out by the colleges and government and industrial agencies.

A factor in the situation which the employers are beginning to appreciate is the attitude which many college graduates exhibit toward the daily routine of their jobs. This attitude is bred mostly by the "lecture and textbook" method of absorbing information as well as by unfamiliarity with the nontechnical problems of industrial life. Perhaps some employers do not make proper allowance in such cases, but they may be assured that the individual with ambition and initiative will soon make his worth apparent. On the other hand there are undoubtedly some practical men in every plant who are naturally ingenious and able to think constructively, who are held back by the lack of formal education and by the manager's hesitancy to trust them with responsibility. Many of these men have already a good understanding of the technical problems of production and also possess that curiosity and daring characteristic of the true experimenter. Such men would profit by taking technical courses of collegiate grade if such were available locally. Extension and correspondence courses would be of comparatively little value to these men. But the dominant idea is that the "boss" ought to furnish the impetus, and it takes very little encouragement on his part to get his men interested in such courses.

Another course open to the small or average-sized plant consists in a more active coöperation with neighboring colleges and technical schools, especially by maintaining a scholarship or a fellowship, the holder devoting all or part time to the technical problem submitted by the company. More than one ceramic concern has found this method very profitable, and in some cases the incumbent of the scholarship has "graduated" into a good position in the plant. This applies especially to certain aspects of the work at the Bureau of Standards, the Bureau of Mines, and Mellon Institute.

Summary

In summarizing the various thoughts and ideas contained in the foregoing paragraphs, it is suggested that:

(1) It is the function of the technical school to impart as complete a scientific foundation as possible to its graduates; consequently the tendency is to produce technologists rather than engineers, this being particularly true of graduate work.

(2) Engineering ability develops as the result of individual traits or inborn qualities and not from formal training; therefore an employer is not justified in assuming that he has solved his problem by hiring a man with a college degree.

(3) The average-size plant should endeavor to make better use of the talents and ability of the so-called practical men on the payroll by encouraging such individuals to acquire technical knowledge through evening courses and extension work. In addition much might be done through coöperative arrangements with local educational institutions especially by maintaining scholarships, either as individuals or collectively or as an industrial association.

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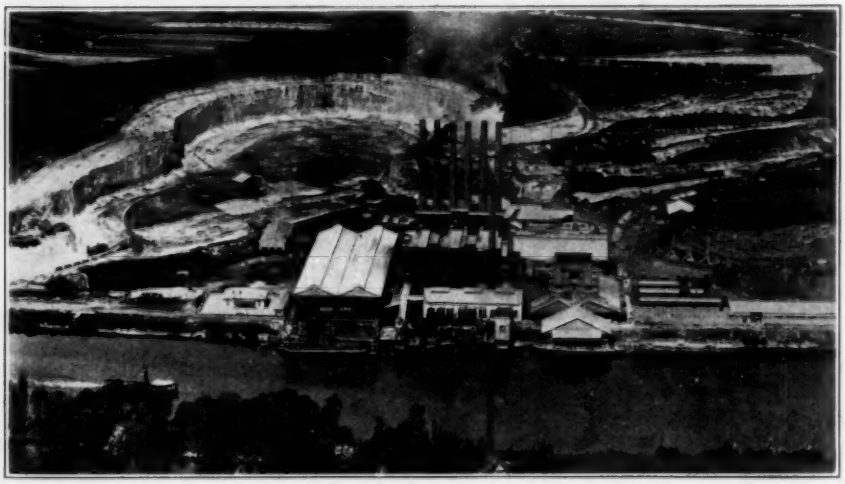

FIG. 2.—Bird's eye view of the artificial Portland cement factory at Gargenville (S. Oise) France, (six rotary kilns.)

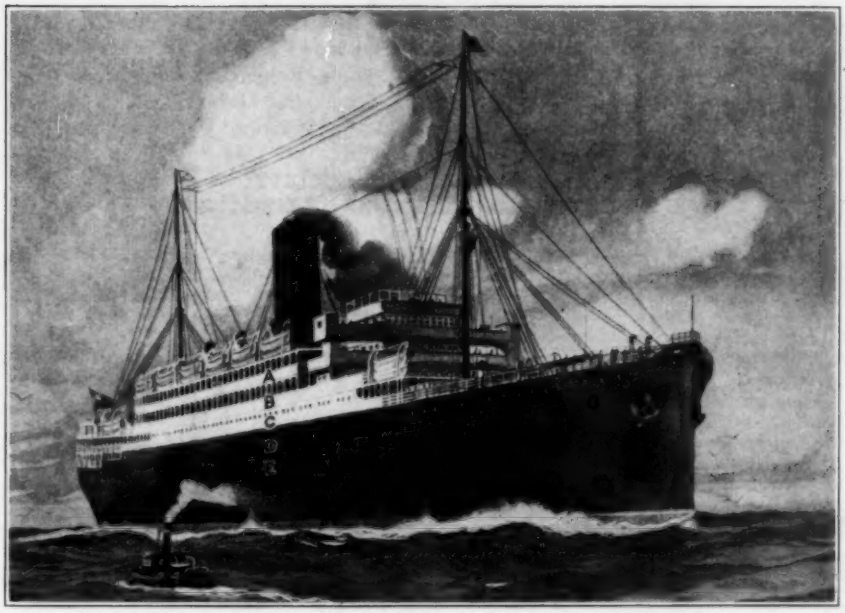

Fig. 3.—S. S. "Tuscania." (Oil Burner) Gross tonnage 16,700, Length 575 feet, Breadth 70 feet.

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AMERICAN CERAMIC SOCIETY

Financial Report for 1927

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Columbus, Ohio.

Columbus, Ohio.
January 7, 1928.

Gentlemen:

I am herein submitting the report of my audit of the accounts of the AMERICAN CERAMIC SOCIETY for the year ending December 31, 1927. The report consists of this letter and attached statements as follows:

I.—Statement of Assets and Liabilities, as of December 31, 1927.

II.—Profit and Loss Statement for the year ending December 31, 1927.

Cash receipts are promptly recorded and deposited in bank, and all payments are made by voucher check duly signed for the SOCIETY by the Treasurer and Secretary and countersigned by the President. Cash balances have been verified and the securities examined. Inventories are carefully taken and conservatively priced.

I hereby certify that it is my opinion that this report correctly shows the financial

operations of the AMERICAN CERAMIC SOCIETY for the year ending December 31, 1927, and the true financial condition at the close of that year.

Respectfully submitted,
A. L. Peters
Certified Public Accountant

STATEMENT I
AMERICAN CERAMIC SOCIETY
I. STATEMENT OF ASSETS AND LIABILITIES
(As of December 31, 1927)

Assets			
Cash in bank (general account)		$2,538.88	
Cash in revolving fund		300.00	$2,838.88
Liberty bonds			9,861.00
Accounts receivable			1,897.53
Inventories			
Journals, 1918–1926		1,693.00	
Journals, 1927		182.00	
Transactions		522.50	
Collective Indexes		102.30	
Bibliographies		310.00	2,809.80
Deferred charge			
European tour expenditures			2,479.21
Furniture and fixtures			2,238.00
Total Assets			22,124.42
Liabilities and Surplus			
Accounts Payable or Notes Payable		None	
Deferred income			
Prepaid dues			
Divisions	$ 722.65		
Corporations	2,539.55		
Personal	5,003.26	8,265.46	
Prepaid *Journals*		1,025.49	
Advance payments on exhibit space		396.04	
Total deferred income			9,686.99
Surplus			
Balance December 31, 1926		10,478.59	
Net income for the year 1927		1,958.84	
Surplus balance December 31, 1927			$12,437.43

STATEMENT II
AMERICAN CERAMIC SOCIETY
PROFIT AND LOSS STATEMENT
(For the Year Ending December 31, 1927)

			Losses	Gains
Net gain on Divisions				$1,199.10
Collective Indexes—Sales		$ 8.90		
Decrease in inventory		1.20		
				7.70
Journal, 1927, sales		3,477.00		
Advertising	$16,706.92			
Less Commissions	1,643.96	15,062.96		
		18,539.96		
Printing (less inventory)	15,952.37			
Abstracts	1,135.47	17,087.84		1,452.12

			Losses	Gains
Journal, 1918–1926, sales		$ 783.29		
Decrease in inventory		679.90		$ 103.39
Reprints, sales		1,078.24		
Costs		1,656.29	578.05	
Seger's Writings, sales		105.00		
Costs		73.58		31.42
Transactions, sales		115.00		
Cost (inc. decrease in inventory)		102.50		12.50
Bibliographies, Sales and Advertising		1,371.50		
Cost (less inventory)		1,345.40		26.10
Totals			578.05	2,832.33
Gain on above activities			2,254.28	
			2,832.33	2,832.33
Above Gain brought down				2,254.28
General Income				
Earned Dues:				
Corporation		6,842.50		
Personal		15,976.87	22,819.37	
Miscellaneous income		44.12		
Less miscellaneous expense		39.15	4.97	
Interest on Liberty Bonds			525.55	
Total general income			23,349.89	
General expenses				
Salaries		13,786.65		
Office expense				
Secretary	2,164.71			
Editor	1,378.41	3,543.12		
Rent		900.00		
Postage		2,063.31		
Traveling Expense		822.33		
Meeting Expense		2,078.49		
Depreciation on Furniture and Fixtures		248.72		
Bad Accounts Written Off		202.71		
Total General Expenses			23,645.33	
Loss on General Items				295.44
Net Income for the Year 1927				$1,958.84

The 1927 Membership Record

The AMERICAN CERAMIC SOCIETY has added 293 members to its roster in the year 1927. This record shows an increase of 56 members over the 1926 total and exactly 100 over that for 1925.

A total of 129 members took an active interest in adding these names. In 1926 only 100 took advantage of this privilege.

More university students are being encouraged by their professors to become student members of the SOCIETY and it is hoped that they will find enough to their interest in its activities to become active members after their college days are ended.

To these 293 new members the AMERICAN CERAMIC SOCIETY extends a hearty welcome.

Membership Worker's Record for the Year

	Corporation
G. Blumenthal	1
E. deF. Curtis	1
V. G. Green	1
R. A. Horning	2
W. F. King	1
J. D. Martin	2
Lois W. Rhead	1
F. H. Riddle	1
G. Simcoe	1
D. F. Stevens	1
T. C. Walker	1
Office	10
Total	22

	Personal
H. Akermann	1
M. G. Babcock	1
C. F. Burchenal	1
C. F. Binns	1
H. Brewer	2
D. Brown	1
T. G. Brown	1
P. P. Budnikoff	1
G. Carlisle	1
W. M. Clark	1
S. E. Cogswell	1
W. E. Cramer	1
J. L. Crawford	1
E. deF. Curtis	6
W. A. Darrah	1
P. Dressler	1
K. H. Endell	1
H. G. Fisk	1
F. C. Flint	1
W. M. Folger	1
V. Foster	1
D. B. Fraser	1
M. L. Freed	1
B. Frosterus	1
C. F. Geiger	5
E. E. Geisinger	1
W. N. Harrison	1
F. M. Hartford	2
F. A. Harvey	1
R. A. Heindl	1
S. E. Hemsteger	1
E. C. Hill	1
F. E. Hodek, Jr.	1
J. W. Hoehl	3
B. M. Hood	1
R. K. Hursh	1
J. E. Hutchinson	1
M. Ichijo	1
J. A. King	1
R. M. King	1
W. V. Knowles	3
T. N. Kurtz	2
R. D. Landrum	1
C. A. Lano	1
P. G. Larkin	1
F. E. Lauer	1
J. B. Lyon	1
P. S. MacMichael	1
A. T. Malm	1
Werner Malsch	1
O. E. Mathiasen	1
H. W. Mauser, Jr.	1
W. K. McAfee	1
T. B. McCoun	1
G. V. McCauley	2
C. B. McComas	2
T. N. McVay	1
C. H. Modes	1
W. G. Molar	1
D. A. Moulton	2
F. P. Nickerson	1
J. P. Nikonow	2
C. L. Norton	1
A. C. Ochs	1
R. J. Paddock	1
C. W. Parmelee	2
H. G. Parsons	1
S. M. Phelps	1
E. P. Poste	1
E. E. Pressler	2
F. H. Rhead	1
F. H. Riddle	1
E. Schramm	1
D. D. Schurtz	1
M. A. Schweiker	1
D. E. Sharp	1
R. F. Sherwood	1
G. Simcoe	2
C. A. Smith	1
D. F. Stevens	1
M. C. Stratton	1
F. G. Sutphen	2
S. D. Swan	1
B. T. Sweely	1
C. F. Tefft	1
W. E. S. Turner	1
E. J. Vachuska	1
W. H. Vaughan	1
T. C. Walker	2
R. T. Watkins	1
M. T. Weaver	1
F. Whitehead	1
H. Wilson	1
H. G. Wolfram	1
E. Zschimmer	2
Office	54
Total	151

	Student
A. I. Andrews	4
G. A. Bole	1
Paul E. Cox	1
C. M. Dodd	1
H. R. Goodrich	1
A. F. Greaves-Walker	4
A. V. Henry	16
R. K. Hursh	5

	Student		Student
W. A. Koehler	1	T. W. Talwalkar	1
Kai-Ching Lu	2	E. J. Vachuska	2
S. Matthews	2	A. S. Watts	1
T. N. McVay	2	F. Westendick	23
J. W. Mellor	1	H. Wilson	3
R. J. Montgomery	3	Office	12
D. A. Moulton	2		
C. W. Parmelee	4	Total	88
R. D. Rudd	1		
J. B. Shaw	2	Total New Members	293

NEW MEMBERS RECEIVED FROM DECEMBER 1, 1927 TO JANUARY 1, 1928

Corporation

Central Refractory Trust, Refractory Materials, U.S.S.R. Moscow, Kusnetzky.

Corhart Refractories Co., Inc., Manufacturer of refractories, 16th and Lee Streets, Louisville, Ky., A. Falck, President.

The River Feldspar Company, 363 Main Street, Middletown, Conn., Geo. E. Worth, Vice President and General Manager, Representative.

Personal

Paul R. Babcock, Starr Porcelain Company, Frenchtown, N. J.

Thomas H. Bradley, 1514 S. Genesee St., Los Angeles, Calif., Salesman, Gladding, McBean & Company.

John R. Braunstein, 112 Wallace Ave., Covington Ky., Student, Univ. of Cincinnati.

Frank B. Daniels, Vice President, Berdin Brick and Tile Company, Goldsboro, N. C.

Mrs. A. R. Dyer, 1644 Elberon Ave., E. Cleveland, Ohio. Instructor, Cleveland School of Art.

C. C. Engle, Vice President and General Manager, United Clay Mines Corporation, Trenton, N. J.

Edwin Stanton Foster, P. O. Box 542, Lincoln, Calif. Ceramist, Architectural Terra Cotta Department, Gladding, McBean & Co.

Conrad W. Given, Foreman Enamel Preparation Department, Cha tanooga Stamping and Enameling Company, Chattanooga, Tenn.

Frank P. Knight, Jr., Spruce Pine, N. C., Chief Chemist, Tennessee, Mineral Products Co.

Thomas F. McNeal, 5 Longwood Road, Baltimore Md., Carr-Lowrey Glass Company, Baltimore, Md.

Herbert A. Miles, Western Sales Manager, United Clay Mines Corporation, Trenton, N. J.

L. R. Nelson, Superintendent, What Cheer Clay Products Co., What Cheer, Iowa.

J. Donald Pearson, Erwin Feldspar Company, Erwin, Tenn.

Luther T. Strommer, 928 E. 149th St., Cleveland, Ohio. Thermal Engineer, American Dressler Kilns, Inc., Cleveland Ohio.

Louis J. Summerhays, 70 Exchange St., Rochester, N. Y. Vice President, Wm. Summerhays Sons Corp., Rochester, N. Y.

Ira C. Williams, 307 Lamar Ave., Maryville, Tenn. Assistant Pyrometric Supervisor, Alcoa Brick and Tile Works, Alcoa, Tenn.

Howard S. Wilson, Harrop Ceramic Service Company, 310 W. Broad St., Columbus, Ohio.

Ernest W. Woodruff, 427 W. Erie St., Chicago, Ill. President, Refractory Products Company, Chicago, Ill.

Gloyd W. Wray, Junior Scientist Ceramic Division, Bureau of Standards, Washington, D. C.

STUDENT

Theodore E. Bach, Univ. of Illinois, Urbana, Ill.
Thomas Bouckly, Univ. of Toronto, Toronto, Can.
D. E. DeVitt, N. Y. State School of Clayworking and Ceramics, Alfred, N. Y.
Gordon E. French, N. Y. State School of Clayworking, and Ceramics, Alfred, N. Y.
John Hillmiller, N. Y. School of Clayworking and Ceramics, Alfred, N. Y.
Hamilton H. Hutchinson, N. C. State College, Raleigh, N. C.
Gordon B. Richardson, Univ. of Washington, Seattle, Wash.
Melville R. Scriven, Univ. of Toronto, Toronto, Can.
John W. Thomson, N.Y. State School of Clayworking and Ceramics, Alfred, N. Y.
J. Edgar Rankin, N. C. State College, Raleigh, N. C.
Donald J. Watson, Iowa State College, Ames, Iowa.
William G. Wilson, Univ. of Toronto, Toronto, Can.
Edwin Wong, Ohio State Univ., Columbus, Ohio.

Membership Worker's Record

	CORPORATION
G. E. Simcoe	1
Office	2
Total	3

	PERSONAL
C. F. Burchenal	1
S. E. Cogswell	1
W. E. Cramer	1
Phillip Dressler	1
H. G. Fisk	1
R. A. Heindl	1
John A. King	1
R. M. King	1
C. A. Lano	1
P. G. Larkin	1
Werner Malsch	1
C. B. McComas	1
E. P. Poste	1
E. E. Pressler	1
Martha T. Weaver	1
Office	4
Total	19

	STUDENT
Paul E. Cox	1
A. F. Greaves-Walker	2
Kai-Ching Lu	1
R. J. Montgomery	3
R. D. Rudd	1
Frank Westendick	4
Hewitt Wilson	1
Total	13
Grand Total	35

PERSONAL NOTES OF MEMBERS OF THE SOCIETY

J. H. Carmichael is located at Kathwood, S. C.

R. D. Cooke has recently resigned as chemist from the Benjamin Electric Company, Des Plaines, Ill., and is connected with the National Enameling and Stamping Company, Granite City, Ill.

James R. Crandall, former ceramic student at Ohio State University is at 212 East 2nd St., Elyria, Ohio.

Waller Crow, formerly president of Waller Crow, Inc., Chicago, Ill., has removed to New Braunfels, Texas where he is vice president of the Dittlinger-Crow Process Company.

The **Electric Refrigeration Corporation,** Leonard Division, has been organized recently. The name of the Grand Rapids Refrigerator Company, was changed to the Leonard Refrigerator Company, the latter then being absorbed by the Electric Refrigera-

tion Corporation. Harold L. Pope will take the place of P. T. Sealy as SOCIETY corporation representative of this firm.

H. E. Fear, formerly representative of Proctor and Schwartz, Inc., Philadelphia, Pa. is now connected with American Dressler Tunnel Kilns, Inc., Cleveland, Ohio.

C. W. Ferguson of the Porcelain Enamel and Manufacturing Co., is located at 1610 Massachusetts Ave., Cambridge, Mass.

A. E. Fitzgerald has moved from Chicago, Ill., where he was employed by the Chicago Pottery Company to Baltimore, Md., Box 935, General Refractories Company.

Leon J. Frost has moved from Nappanee, Ind., to 130 Roselawn Ave., Toronto, Can.

Robert Galbraith has removed from Pine Bluff, Ark., to Crystal Lake, Ill. He is still associated with the American Terra Cotta Company.

Edward S. Hanson has moved from Newark, N. J. to 18 Park Place, Brooklyn, N. Y.

Frank Humpel is living at 26 East 33rd St., Bayonne, N. J., having recently moved from Chicago.

J. B. Krak, technical editor of *Glass Industry*, has joined the Ceramic Department of the Roessler and Hasslacher Chemical Co., Perth Amboy, N. J. to take charge of the glass research and technical service work in connection with production and sale of glass makers' chemicals. Mr. Krak will continue his editorial work with *Glass Industry*.

By order of the Circuit Court, the name of Samuel Leibowitz has been changed to **S. M. Leidy.** Mr. Leidy is manager of the Maryland Chemical Company, Baltimore, Md.

C. C. Leigh, ceramic chemist of the Color Products Company, formerly known as the Chicago Glass Company, announces that this company has moved from 627 West Lake St., to 1220 Webster Ave., Chicago, Ill.

J. P. Leinroth, Public Service Electric and Gas Company, 80 Park Place, Newark, N. J., will serve as corporation representative for the American Gas Association in place of H. H. Clark.

Walter T. Lippert has moved from Bridgeton, N. J. to 2107 West Main St., Belleville, Ill.

E. F. Lundeen of the American Rolling Mill Company, Middletown, Ohio, has been made corporation representative of his Company in the SOCIETY, in place of J. A. Aupperle. Mr. Aupperle has withdrawn from direct activities of the Company because of illness.

Mahlon E. Manson, formerly chemist with the Rundle Mfg. Company, Milwaukee, Wis., is now associated with the Chicago Hardware Company, North Chicago, Ill.

W. Keith McAfee, of Cambridge, Ohio, has been appointed vice president and general manager of the Universal Sanitary Mfg. Company, New Castle, Pa. He has moved from Cambridge, Ohio, where he has been connected with the Cambridge Sanitary Mfg. Company.

Paul Neigsch, Porcelain Enamel and Mfg. Company, has removed to 18 Sandwell Road, Handsworth, Birmingham, England.

Eben Rogers, Jr., has moved from Atlanta, Ga. to 531 Summit St., Alton, Ill.

The membership of **Burrows Sloan,** vice president, General Refractories Company, Philadelphia, Pa., has been transferred to Russell P. Heuer, formerly of the University of Pennsylvania.

Otto O. Springe, is superintendent of the Alton Brick Company, Alton, Ill.

Charles A. Smith, who for several years has been employed by the A. P. Green Fire Brick Company, Mexico, Mo., has accepted a position with the Bigelow-Liptak Corporation, 5057 Woodward Ave., Detroit, Mich.

Franklin S. Thompson, former ceramist with Sayre and Fisher Company, Sayreville, N. J., is now with the Hanley Co., Inc., Summerville, Pa.

Bruce F. Wagner, formerly of Cleveland, Ohio, where he was associated with the Ferro Enamel Supply Company, has moved to Niagara Falls, N. Y. and is now affiliated with the Titanium Alloy Mfg. Company.

S. Wiester has moved from Ironton, Ohio to 2322 8th Ave., Beaver Falls, Pa.

Wilbur R. Wyckoff has left the M. D. Valentine & Bros. Company, Woodbridge, N. J. and is now with Sayre and Fisher Company, Sayreville, N. J.

WHERE ARE THESE MEMBERS?

Letters addressed to the following persons have been returned to the office of the AMERICAN CERAMIC SOCIETY marked "Adress Unknown." Kindly check over these names and notify the Secretary's office if there are any persons named here about whom you have information?

Francis E. Allen, What Cheer Clay Prod. Co., What Cheer, Iowa.
G. V. Baker, Supt. Penn. Feldspar Co., Barnard, N. Y.
J. F. Bardush, Grand Rapids Refrigerator Co., Grand Rapids, Mich.
Randolph H. Barnard, c/o Illinois Glass Co., Gas City, Ind.
E. R. Beidler, 356 E. National Ave., Brazil, Ind.
W. J. Bidleman, Chicago Fire Brick Co., 1321 Conway Bldg., Chicago, Ill.
Donald W. Boddy, Tennessee Furniture Corp., Chattanooga, Tenn.
Sarah H. Bonesteele, Victor, N. Y.
George O. Bowles, New Cumberland, W. Va.
James M. Boyd, 16 Melbourne Road, Norwalk, Conn.
E. L. Butler, 111 W. Washington St., Chicago, Ill.
J. P. Callaghan, c/o Teaque Hotel, Montgomery, Ala.
Wm. T. Christian, 1303½ E. 12th St., Des Moines, Iowa.
G. Roger Coats, 610 Wesley Bldg., Philadelphia, Pa.
Harvey W. Culp, c/o Babcock & Wilcox Co., East Liverpool, Ohio.
Ellen W. Cushing, 138 Marlboro St., Boston, Mass.
Lewis T. Decker, 816 Carteret Ave., Trenton, N. J.
J. C. De Kort, c/o Warwick China Co., Wheeling, W. Va.
Charles S. Dolley, Keramoid Mfg. Co., Fort Madison, Iowa.
George C. Dougherty, 54 Crestmont St., Reading, Pa.
Horace Drever, 1015 Chestnut, Room 705, Philadelphia, Pa.
E. W. Ekstrand, 1337 S. Elm St., Alhambra, Calif.
Ernest G. Enck, 1421 Arch St., Room 524, Philadelphia, Pa.
A. H. Goodman, Box 915, Pittsburgh, Pa. (Sales Engineer).
H. Goulding-Brown, 28 Titchborne St., Hyde Park, London W-2, England.
John S. Grainer, 4238 E. 122nd St., Cleveland, Ohio. (Vitreous Enameling Co.)
Russel H. Grainer, 211 Mill St., Beaver Dam, Wis.
John L. Greenwood, Supt. Lehigh Sewer Pipe & Tile Co., Lehigh, Iowa.
John S. Halbert, 7409 N. Ashland Blvd., Chicago, Ill.
W. S. Hamilton, Celite Products Co., Lompoc, Calif.
George R. Harvey, 448 Barton St., Hamilton, Ont., Canada.
Yuzo Haahimoto, c/o M. Shofu—Far East Trading Co., 32 Union Square, New York, N. Y.
E. M. Hernandeth, 4419 Victorine St., Los Angeles, Calif.
William E. Irish, Erie City Iron Works, Erie, Pa.
Henry P. Kimbell, 72 Emerald St., S. Hamilton, Ont., Canada.
Wm. H. Landers, St. Louis Lithopone Co., Collinsville, Ill.
John J. Lawler, 839 Thomas Ave., Forest Park, Ill. (Allied Industrial Products Co., 120 N. May St., Chicago, Ill.)
Henry F. Lee, 4611 Compton Ave., Los Angeles, Calif.
Charles G. Lippert, 2513 S. Boots St., Marion, Ind.
Gilbert McCall, 8018 K Street, Sacramento, Calif.
Leigh J. McGrath, 1540 S. Walnut St., Casper, Wyo.
Hyman S. Magid, Y. M. C. A., Kokomo, Ind.
Willis S. Mellott, 7102 Mt. Vernon St., Pittsburgh, Pa. (Eureka Fire Brick Co.)
L. H. Menne, Peoples Gas Stores, Chicago, Ill.
James T. Murphy, Webster Hall, Detroit, Mich., (Cowles Detergent Co.).

C. E. Owen, Box 108, E. Liverpool, Ohio. (Babcock & Wilcox Co.)
John W. Patterson, Western Sheet Glass Co., Torrance, Calif.
J. Donald Pearson.
W. H. Pelletier, Ferro Enameling Co., 4150 E. 56th St., Cleveland, Ohio.
Wilson A. Philips, 309 Fifth Ave., New York, N. Y.
F. B. Porter, 204½ Houston St., Fort Worth, Texas.
Robert Roadhouse, Strong Mfg. Co., Sebring, Ohio.
John V. Rock, 14610 Fielding Ave., Brightmore, Detroit, Mich.
Wm. A. Rofe, Pacific Beach, San Diego, Calif.
Malcolm C. Sargent, 163 Norfolk St., Wollaston, Mass.
Antonio Scalise, Columbia Glass Co., Fairmont, W. Va.
Frank C. Schultz, Fiske & Co., Darlington, Beaver Co., Pa.
Oliver E. Schumacher, 717 Crenshaw Blvd., Los Angeles, Calif.
Chas. S. Shoemaker, 328 Main St., Belle Vernon, Pa.
Earl Stewart, St. Andrews' College, Saskatoon, Sask., Canada.
Justin C. Sturn, 1342 Dearborn St., Lincoln Park Sta., Chicago, Ill.
G. Richard Thomas, R. Thomas & Sons Co., East Liverpool, Ohio.
Ruth D. Whitford, No. 3, 8015 Euclid Ave., Cleveland, Ohio.
J. A. Wilson, Bixler Apts., Kittanning, Pa. (Pittsburgh Plate Glass Co.)
John Winkler, 11000 Woodstock Ave., Cleveland, Ohio. (Cleveland Enameling Mfg. Co.)

NOTES FROM CERAMIC SCHOOLS

New York State School of Clayworking and Ceramics

The Student Branch of the AMERICAN CERAMIC SOCIETY of the New York State School of Clayworking and Ceramics has completed another semester of active work at Alfred University.

The Branch has eighty-five members, more than ever before and by more varied programs has become more active.

The meetings are held twice a month and after the business, some form of educational information is given, usually by the aid of motion pictures, slides or lecturers. Some of these films have been: The Manufacture and Use of Fireclay Refractories; The Manufacture and Use of Face-brick; and the Potter's Wheel.

The officers for this year are: President, William G. Collins; Vice-President, Francis J. Williams, Secretary; Norman H. Stolte, and Treasurer, Abde Ally.

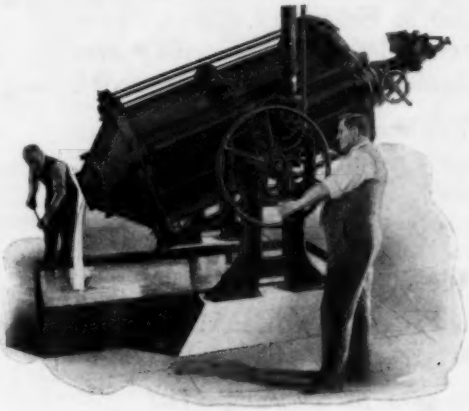
CALENDAR OF CONVENTIONS

AMERICAN CERAMIC SOCIETY		
Annual Meeting	Feb. 5–11, 1928	Atlantic City, N. J.
Ceramists' Tour Abroad	May 19–July 5, 1928	
Amer. Chemical Society	April 16–20, 1928	St. Louis, Mo.
Amer. Concrete Institute	Feb. 28–Mar. 1, 1928	Philadelphia, Pa.
American Electrochemical Society		
(Spring Meeting)	April 26–28, 1928	Bridgeport, Conn.
(Fall Meeting)	Sept. 20–22, 1928	Charleston, W. Va.
Amer. Foundrymen's Assn.	May 14–18, 1928	Philadelphia, Pa.
Amer. Gas Assn. (Natural Gas Dept.)	May, 1928	Dallas, Texas
Amer. Institute of Architects	May 9–11, 1928	St. Louis, Mo.
Amer. Inst. Mining and Met. Engrs.	February, 1928	New York City
Amer. Soc. Mechanical Engineers		
(50th Anniversary)	April 7, 1928	Washington, D. C.
(Spring Meeting)	May 14–17, 1928	Pittsburgh, Pa.

Amer. Soc. Steel Treating		
(Semi-Annual Meeting)	Feb. 16–17, 1928	Montreal, Can.
(Annual Meeting)	Oct. 8–13, 1928	Philadelphia, Pa.
Amer. Zinc Institute	April 16–18, 1928	St. Louis, Mo.
Assn. of Sci. App. Makers of Amer.	May 5–7, 1928	Atlantic City, N. J.
Common Brick Manufacturers Assn.	Feb. 13–17, 1928	Washington, D. C.
Engineering Foundation	Feb. 16, 1928	New York City
Glass Container Assn.	Feb. 2–3, 1928	New York City
Hollow Building Tile Assn.	February, 1928	Chicago, Ill.
Mfg. Chemists Assn. of U. S.	June 2, 1928	New York City
Natl. Acad. of Sciences	April 23–25, 1928	Washington, D. C.
Natl. Assn. of Mfgrs.	Oct., 1928	
Natl. Assn. Mfgrs. Heating and Cooking Appliances	May 9–10, 1928	Detroit, Mich.
Natl. Brick Mfgr. Assn. (Meeting jointly with the AMERICAN CERAMIC SOCIETY)	Feb. 5–11, 1928	Atlantic City, N. J.
Natl. Clay Prod. Ind. Assn.	April, 1928	Chicago, Ill.
Optical Soc. of Amer.	October, 1928	Washington, D. C.
Sand-Lime Brick Assn.	Feb. 1–3, 1928	Washington, D C.

U. S. Rotary Enamel Smelting Furnaces Give

SATISFACTION



Excellent Results Best Demonstrated by Large Number of Repeat Orders

Crane Enamelware Company, Chattanooga, Tennessee.
Kohler Company, Kohler, Wisconsin.
Porcelain Enamel & Mfg. Company, Baltimore, Md.
Ingram-Richardson Mfg. Company, Frankfort, Ind.
Ingram-Richardson Mfg. Company, Beaver Falls, Pa.
Ingram-Richardson Corporation, Bayonne, N. J.
Grand Rapids Refrigerator Co., Grand Rapids, Mich.
Columbian Enameling & Stamping Co., Terre Haute, Ind.
Sheet Metal Products Company, Toronto, Canada.
Republic Metalware Company, Buffalo, N. Y.
Pacific Sanitary Mfg. Company, Richmond, California.
A. Weiskittel & Son Company, Baltimore, Md.
Malleable Iron Range Company, Beaver Dam, Wis.
Edison Electric Appliance Co., Inc., Chicago, Ill.
Welsh Tinplate & Metal Stpg. Co., Ltd., Llanelly, England.
Ernest Stevens, Limited, Cradley Heath, England.
Ward Leonard Electric Company, Mount Vernon, N. Y.
American Enameled Products Co., Chicago, Ill.
Michigan Porcelain Tile Works, Ionia, Michigan.
Stanley Insulating Company, Great Barrington, Mass.
Roesch Enamel Range Company, Belleville, Ill.
L. D. Caulk Company, Milford, Delaware.

SIZES AND CAPACITIES

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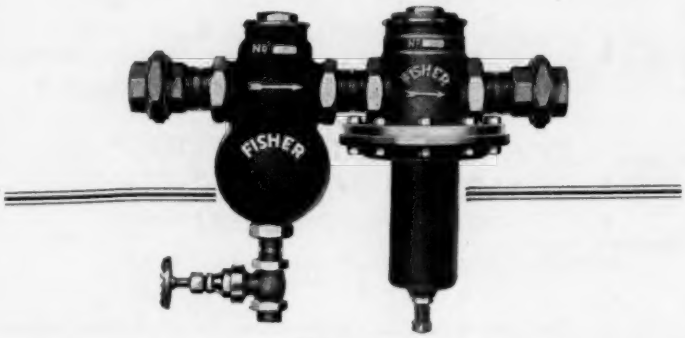

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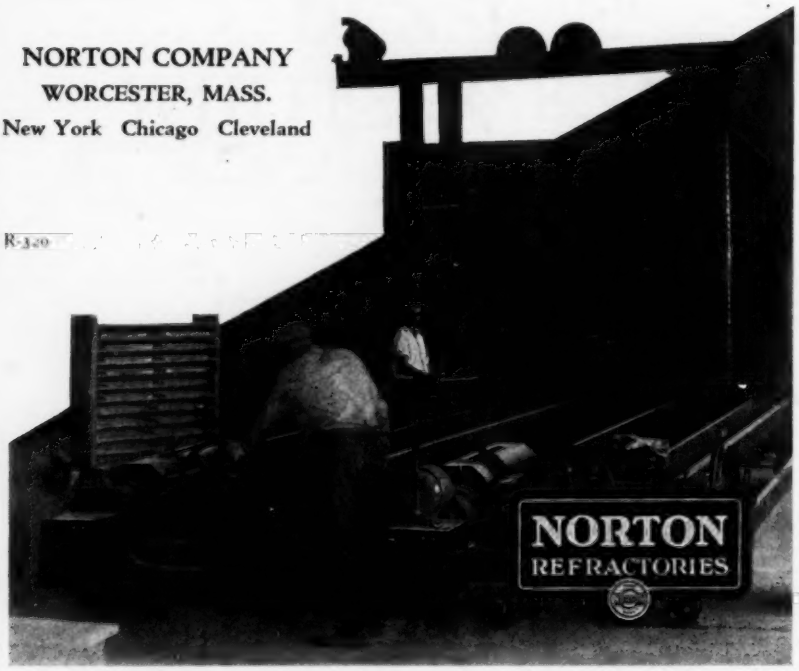

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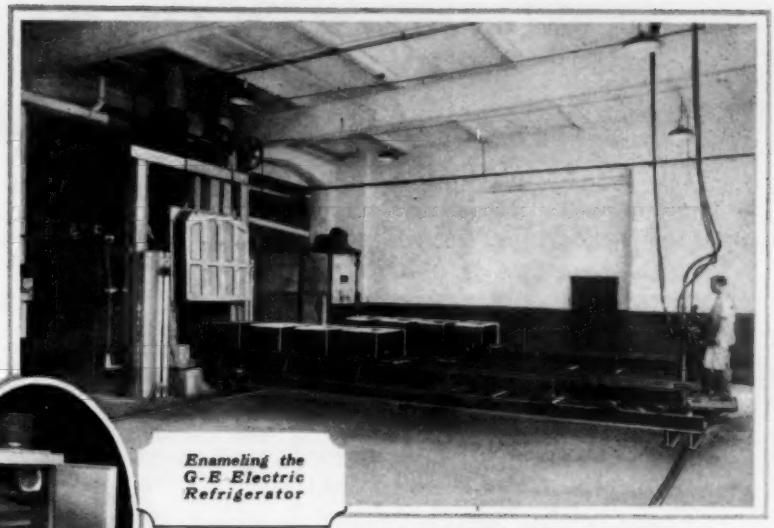
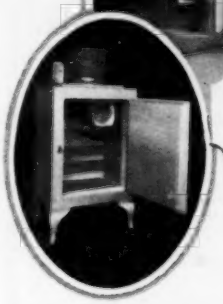


Enameling the G-E Electric Refrigerator



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CERAMIC BREVITIES

The Pennsylvania Salt Manufacturing Company announces the following changes in Executive Organization as of January 1, 1928.

Mr. N. Emory Bartlett, who has been with the Company since November, 1893, has been elected a Vice-President, and will also continue his duties as General Sales Agent.

Mr. Y. F. Hardcastle, who has been connected with the Wyandotte Plant since January, 1910, has also been elected a Vice-President, and will have charge of the manufacture of the Chlorine products at the present plants at Wyandotte and Menominee, Michigan, and will also superintend the construction of the new plant at Tacoma, Washington.

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THIS is a new type of much interest to the Ceramic industry—a direct fired kiln, burning oil, producing glazed ware formerly burned in muffle kilns.

¶The necessary control of kiln atmosphere and temperature is obtained by the use of Carborundum Carbo-Radiant Combustion Chambers.

¶No muffle is used. This reduces the fuel consumption by approximately 40 per cent.

¶This direct firing method eliminates the lag in heating and cooling which occurs when muffles are used thus giving a quicker kiln turnover.

¶This kiln is operated with two or four oil burners instead of the usual eight to fourteen.

¶The costly maintenance of muffles and fireboxes is eliminated, as well as loss of production due to shutdowns.

¶Simplicity of heat control—economy of operation—a clean kiln atmosphere and a reduction of spoiled ware is assured with the use of this kiln.

¶The kiln being rectangular is easy to load and unload. It gives the maximum kiln capacity for the floor space occupied.

¶Since burners are located at front and rear, these kilns may be built in battery with no waste space between kilns.

The Carbo-Radiant Direct Fired Kilns are designed and built by The Carborundum Company, Perth Amboy, N. J.

THE CARBORUNDUM COMPANY, PERTH AMBOY, N. J.

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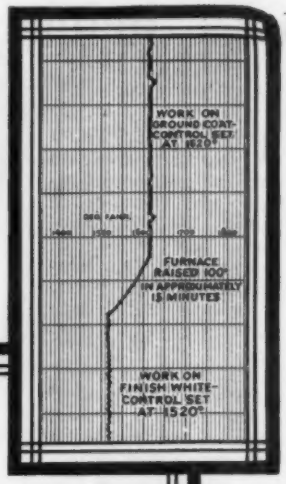
Without prejudice!


WORK ON GROUND COAT-CONTROL SET AT 1520°
FURNACE RAISED 100° IN APPROXIMATELY 15 MINUTES
WORK ON FINISH WHITE-CONTROL SET AT 1520°

THIS CHART SHOWS

how gas was regulated for two different jobs.

The first job required a temperature of 1520 degrees Fh.

The next job demanded a heat of 1620 degrees Fh.

It took only fifteen minutes to increase the heat 100 degrees.

There is nothing sympathetic or sentimental about an automatic recording instrument. It just registers the facts, and lets them speak for themselves.

The facts revealed by this chart show that Gas Heat gives Control, Speed, Increased Production, Uniform Production, and No Spoilage; all elements that make for economy in operation, and consequently increase in profit.

You would like information concerning the use of gas as a fuel in your own factory, and can easily obtain it by writing to your own gas company, or to

American Gas Association
420 Lexington Avenue, New York City

YOU CAN DO IT BETTER WITH GAS

How *Giuseppe* wrote history that helped build an industry

Incidents That Have Pointed the Way— No. 2 of a Series.

TEN YEARS AGO Giupesse went to the big steamship office and bought a ticket. Then, bending under the weight of two heavy bags, Giuseppe trudged up the gangplank and made his way to the steerage.

His destination? America! The land of opportunity! Several days at sea and then Giuseppe's eyes beheld that which to him had been through all his childish dreams the center of his life, the dawn of a new light, the very heart of the universe—the Statute of Liberty.

One day a few years later, Giuseppe went to work in a big steel mill, and there, standing in the bright glare of one of the huge furnaces, was an old steerage friend, Steve Moreno. Each recognized the other as two brawny hands shot out and clasped joyously.

"Fine place to work," drawled Steve. "Yes, fine place. My boss help you to get your 'papers.' Got 'papers' yet, Giuseppe?"

Steve had to explain what he meant by "papers," how the boss helped him to pass the examination and become naturalized, an American.

Giuseppe's boss heard of the struggle toward citizenship and lent a helping hand. He told Giuseppe how to apply for the "papers," with their ribbons of red, white and blue.

Weeks of laborious study followed. Bit by bit Giuseppe mastered the "American language."

At last a great day came which was to make him an American—he went up for examination.

Presently Giuseppe labored over his first letter to a company official.

"Now I am an American and I thank you, kind sir, for helping me," it read.

This one immigrant's simple letter gave birth to a real enthusiasm for Americanization work, which is now an important part of the industrial training conducted by The American Rolling Mill Company.

The pen that wrote Giuseppe's simple letter of gratitude has inscribed an important chapter in industrial history.

Today more than 90 per cent of the foreign-born workers on the company's pay-roll are American citizens!

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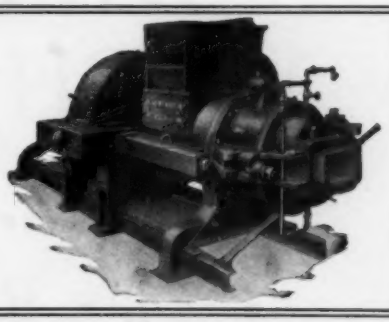

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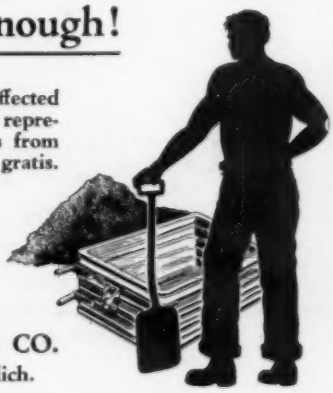

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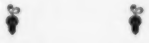
If you do not think this year's annual meeting and exhibit is going to be worth while, think this over: Forty-two booths were planned and taken by the first of December. Eight additional booths had to be erected and all told, there are forty-five companies exhibiting their material and equipment.

It was necessary to refuse the applications of a number of companies because of lack of hotel room to erect booths.

Every exhibitor will have from two to five representatives on hand to explain anything you may want to know regarding their equipment or material.

These exhibitors know the value of this meeting and are going there prepared to make the most of it. Will you?



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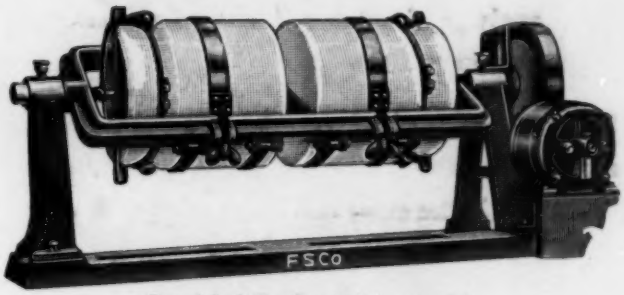
BALL MILLS

for the Ceramist



One of the ball mills which is accurately described in the Fisher Catalogue. See special section devoted to Crushers, Grinders and Mills, Page 275

THE efficiency of this method of reducing materials to the finest powders is rather astonishing to those who have not previously used a ball mill. This mill offers a convenient and practical means of reducing ceramic materials to a very fine powder or flour, as well as a means of properly and thoroughly mixing these materials.

Their is no danger of contamination as the operation is performed in a sealed porcelain jar with flint pebbles. These jars are vitreous and impervious, colors, dyes and inks can be ground without discoloration to the jar.

The mill illustrated, 8-380, is furnished with either AC or DC motor and is complete with two charges of flint pebbles. Price, $140.00.

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Furthermore, owing to a characteristic size and grain of material obtained by our process of manufacture, a more dense and more uniform opacity is obtained than in any other make.

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